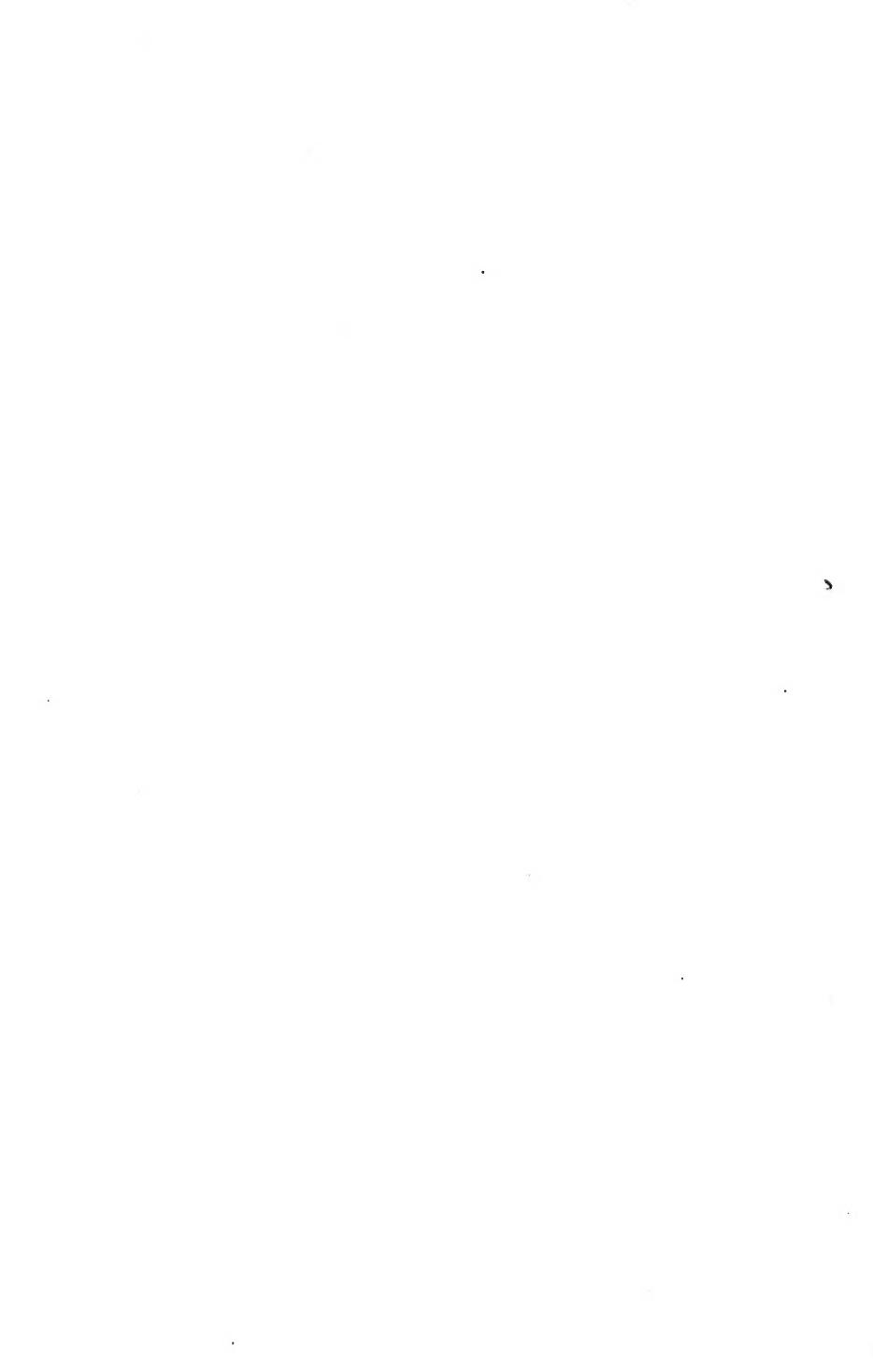




HAND-BOOK

AND

SELF-TEACHER,

FOR THE

Local Marine Board of Canada,

COMPRISING A SERIES OF

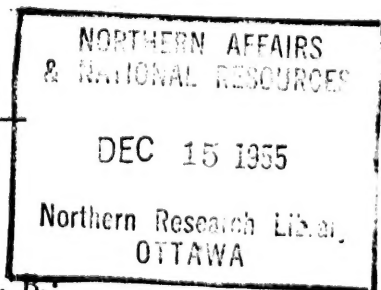
QUESTIONS WITH ANSWERS AND EXPLANATIONS.

BY

CAPT. R. CONNOLLY,

Teacher of Navigation and Nautical Astronomy,

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PREFACE.

In preparing this SELF-TEACHER for the young and inexperienced Mariner, I have begun at the beginning, and explained the Tables to be used, the method of using them, with the numbers of the pages, and several examples for correcting seconds and tenths. My reason for so doing is, that in my experience as teacher, I have known pupils to have been kept days seeking for the Tables and explanations, not knowing how to use them at sea, having had no one to instruct them. This work will prove a valuable guide for them previous to attending the school to prepare for examination.

In conclusion, the young Navigator will find on perusing this little book, that I have left no stone unturned to make all that is necessary for passing an examination as simple as possible, and that he will find pleasure and benefit in the perusal of its pages, whether he is at sea, and when at anchor, or lying in harbor.

R. CONNOLLY.

N. B.—I would feel grateful to any of my friends who may find discrepancies in this work, to tell or communicate with me, as some may have crept in; having had no assistant, I have worked every question myself.

NOTICE.—I have in press, and shall shortly publish a book entitled "SEAMANSHIP SIMPLIFIED," which I think will prove of great value to young Mariners.

ERRATA.

Page 9.—+ Logs for Answer, read 4884.

- " 14.—Parallel sailing, 5th Question, read $2^{\circ} 10' W$.
- " 15.—Mercator's sailing, 1st Example for distance, read 1034.
- " 20.—Tides, Tanera, read A. M. 1.3, P. M. 1.44.
- " 21.—St. John Tide, read A. M. 14', P. M. 33'.
- " 32.—Day's Work, for Lat. left read $51^{\circ} 25'$.
- " 34.—Day's Work, read course S. $33^{\circ} 30' W$., Dist. 88 miles; Lat. in $50^{\circ} 11' N$., Long. $11^{\circ} 6' W$.
- " 35.—Day's Work, read Long. $75^{\circ} 00' W$.
- " 43.—Last line Answer, $21^{\circ} 59' 57'' S$.
- " 46.—First Question, read Lat. $68^{\circ} 9' 19'' N$.
- " 47.—First Question, read April 30th.
- " 49.—Amp., read Long. $150^{\circ} 10' E$., Dev. $5^{\circ} 5' 30'' E$.
- " 51.—Deviation, read $2^{\circ} 45' E$.
- " 51.—April 10th, read 5h. 30m.
- " 54.—Example 3rd, read fast, — for gaining, read losing.
- " 56.—First Question, read 2m. 9s.
- " 83.—Ex Meridian, Lat. read $52^{\circ} 32' S$.
- " 86.—Star, read Lat. $26^{\circ} 50' 47'' S$.
- " 90.—Deviation, Ship's head at N. E., read $15^{\circ} 37' E$.
- " 92.—Chr., read Long. by Acct. $75^{\circ} 12' W$.; Chr. 8h. 20m. 20s.
- " 94.—Ex Meridan $\odot S$.
- " 131.—Chr. Long., read Long $166^{\circ} 51' 45'' W$.
- " 132.—Day's Work, read Course S. $15^{\circ} W$.; Long. $176^{\circ} 56' W$.
- " 134.—Day's Work, read Lat. in $52^{\circ} 59' N$.
- " 135.—Stars Dec., read $12^{\circ} 34' 18'' N$.

LOGARITHMS.

The Natural number is found in Table XXIV, Norie, pages 88 to 103; also, the Mantissa corresponding thereto, and is found by looking at the left of page under No. at top; it extends to 999. Required, the Log. corresponding to 999. Look in page 103 and under No. left side of page, and under 0 from top the Log. is 99956. Next, require the Log. corresponding to 9999. Look for the first three figures as above, and the fourth at the last column under 9,—the answer will be 99957.

But it often happens that the Log. of more than four figures is required, then proceed thus: Find the first four figures as above, then the remaining figures, multiply by the value found in column marked Diff. at right of page, and cut off as many as are over four in the Natural No., and if only one, cut off one; but if two, cut off two, and all in excess accordingly. See the following examples:—

Required, the Log. of 22222. The value of the first four figures is 346744; now you require the value of the fifth or remaining figure 2,—the diff. in column is 195 multiplied by 2: $2 \times 195 = 390$; then by cutting off one figure from 390, leaves 39 to be added: $39 + 346744 = (\text{equal}) 346783$.

Next, find the Log. of 333333. The value of the first four is 522835, and the diff. is $130 \times 33 = 42.90$, or 43: $43 + 522835 = (\text{equal}) 522878$.

Again, find the value of 4444444. Find the first four as above, and in diff. column stands 98 multiplied by the last three figures,—the answer is 647818.

Again, find the value of 66666666. Find the value of the first four figures as stated above,—which is 823865, and the diff. is 65 multiplied ($\times$) by the four remaining figures gives 823908.

 See following page for questions worked.

N. B.—If the figures cut off are under 5, 50, 500, reject them; but if over, add one more to the Mantissa.

NATURAL NUMBER GIVEN TO FIND LOGARITHM.

Nat. No. 22222.	346744	195 Diff.
	+ 39.	× 2 excess of four (see page 5.)
Ans. =	346783	• 39·0

Nat. No. 333333.	522835	130 Diff.
	+ 43.	× 333 excess of four.
Ans. =	522878	• 390
		• 390
		• 390
		• 43·290

Nat. No. 4444444.	647774	444 excess of four.
	+ 44.	× 98 Diff.
Ans. =	647818	• 3552
		• 3996
		• 43·512 or 44.

Nat. No. 66666666.	823865	6666 excess of four.
	+ 43.	× 65 Diff.
Ans. =	823908	• 33330
		• 39996
		• 43·3290

EXAMPLES FOR EXERCISES.

1. Nat. No. 22.	Ans. 1·342423.
2. " " 333.	" 2·522444.
3. " " 4444.	" 3·647383.
4. " " 55555.	" 4·744723.
5. " " 666666.	" 5·823909.
6. " " 7777777.	" 6·890856.
7. " " 123401.	" 5·091319.
8. " " 1234002.	" 6·091326.
9. " " 12340003.	" 7·091315.

Every Natural number requires an Index, and is one less than the number itself—(see examples above); and the Index to a

mixed number is one less than the whole numbers contained in the question:—the index to $1\cdot23$ is 0 ; to $12\cdot3$ is 1 ; to $123\cdot4$ is 2 ; $1234\cdot5$ is 3. The first contains only one whole number, and 0 is less than one ; the second, two whole numbers, and one is less than two. Therefore, all indices are found accordingly, and will be easily found in the following examples.

INDICES FOR MIXED NUMBERS.

The index for a mixed number is one less than contained in the whole number and stands thus:—

The figures to the left are the whole numbers, and those to the right are called mixed.

	$2\cdot345=0.$
	$12\cdot345=1.$
	$123\cdot345=2.$
	$1234\cdot345=3.$
	$12345\cdot345=4.$

In taking whole and mixed numbers from the Tables, take them out as if they were all whole, the index only is changed.

Ex.—Find the Log. of $2\cdot345 = 0\cdot370133$. It is quite clear that you cannot have but 0 in the index, as there is only one whole number in the question, the rest being mixed numbers.

LOG. OR MANTISSA GIVEN TO FIND NATURAL NUMBER.

In the above examples the Natural number calls for one figure less, and if the Log. be given to find the Nat. number, that number must contain one more whole number than the index of Log. given. Suppose the Nat. No. of Log. $3\cdot468790$ be required. Find the Log. in Table XXIV, and in No. at left side will be found 294, and at the top of the page will be found 3, which is to be placed after—2943--and gives the answer, as the index is 3 it calls for four whole numbers. Again, if the Nat. No. $5\cdot361335$ be required, this cannot be found to agree with any number, so take the next less, 361161, and the difference between them is 174 by annexing two cyphers, and divide by the number 189 found in diff. col. gives 96 to be placed after the figures found in No. col. and under the top figure gives answer, 229796. It is plain that the index calls for six figures, and they must be found by the above rule. But if the Log. could be found to agree, then sufficient cyphers may be added to make up for what the index calls for. It must be remembered that only one cypher must be added at a time. See the following examples.

EXAMPLES.

1st.—Natural No. corresponding to Log. $0.115278 = 1.304$. The decimal point placed between first and second, as index 0 requires one whole number.

2nd.—Log. 1.115278 . Ans.— 13.04 . Index between second and third.

3rd.—Log. 4.432789
next less, 432649

Ans. 27088.8 $160)1400(88$
 1280

 1200
 1280

 800
 890

And 5.432789
next less, 432649

Ans. $270887.5 = 160)1400(875$
 1280

 1200
 1120

 800
 890

In the above example the index called for five whole numbers. By a cypher added to the difference between the given Log. and the next less, and divided by diff. of col. at right side gives 88 nearly, annexed to the four figures found, and decimal point placed after fifth, gives answer.

The index five requires six whole numbers. Two cyphers are added to find the required number, then, as there is a diff. of 80 over, another cypher is added, which gives one more, and it is a decimal.

THE NATURAL NUMBER REQUIRED FOR THE FOLLOWING LOGS.

	Ans.	Logs.
1.	1.7607	0.245678
2.	22.1657	1.345678
3.	286.278	2.456789
4.	9719.7	3.987654
5.	95255.7	4.876543
6.	451144.68	5.654321
7.	4641571.3	6.666666
8.	59948216.7	7.777777
9.	129155223.3	8.111111
10.	9999571627.9	9.999999

MULTIPLICATION OF LOGARITHMS.

Add the Logs. of the multiplier and the multiplicand, the Nat. number corresponding thereto will be the answer.

$$\begin{array}{r} \text{Multiply } 22 = 1.342423 \\ \text{by } 222 = 2.365488 \\ \hline \end{array}$$

$$\text{Ans. } 5104 = 3.707911$$

In this example the sum of Logs. was found to agree abreast of 510 in Nat. No. col., and under the 4 from top, gives the answer, 4 whole numbers, as index is 3.

$$\begin{array}{r} \text{Mul. } 22 \cdot 2 = 1.346352 \\ 222 \cdot 2 = 2.346744 \\ \hline \end{array}$$

$$\begin{array}{r} \text{Ans. } 4932 \cdot 84 = 3.693097 \\ 693023 \text{ n. less.} \\ \hline \end{array}$$

$$\begin{array}{r} \text{Diff. } 88)740(84 \\ 704 \\ \hline \end{array}$$

$$\begin{array}{r} 360 \\ 352 \\ \hline \end{array}$$

$$8$$

The general rule is, there ought to be as many decimals in the answer as are in both numbers.

$$\begin{array}{r} \text{Multiply } 333 = 2.522444 \\ 4444 = 3.647774 \\ \hline \end{array}$$

$$\begin{array}{r} \text{Ans. } 1479850 = 6.170218 \\ 169968 \text{ n. less.} \\ \hline \end{array}$$

$$\begin{array}{r} \text{Diff. } 294)2500(850 \\ 2352 \\ \hline \end{array}$$

$$1480$$

$$1470$$

$$100$$

In the above example, the index being 6 called for 7 whole numbers, therefore, cyphers had to be added to find enough in the quotient to annex the first four figures found.

QUESTIONS FOR EXERCISE.

$$\text{Multiply } 234 \text{ by } 456.$$

$$\text{" } 8456 \text{ by } 42.$$

$$\text{" } 25 \cdot 4 \text{ by } 29 \cdot 7.$$

$$\text{" } 289 \cdot 4 \text{ by } 2 \cdot 46.$$

$$\text{Ans. } 106704.$$

$$\text{" } 145152.$$

$$\text{" } 754 \cdot 38, \text{ nearly.}$$

$$\text{" } 711 \cdot 92, \text{ nearly.}$$

DIVISION OF LOGARITHMS.

There is no necessity for many examples in Division, as it is performed similar to Multiplication, only that one Log. is subtracted from the other, also the index, and the answer is found as in Multiplication.

$$\begin{array}{r} \text{Divide } 4789 = 3.680245 \\ \text{by } 842 = 2.925312 \\ \hline \end{array}$$

$$\text{Ans. } 5.687 = 0.754933$$

$$\begin{array}{r} \text{Divide } 47.94 = 1.680698 \\ \text{by } 1.29 = 0.110590 \\ \hline \end{array}$$

$$\text{Ans. } 37.16 = 1.570108$$

TABLE XXV.

LOGARITHMIC SINES, SECANTS, TANGENTS, &c.

These tables are very essential, as they are employed in solving five of the questions that are proposed at the Examination Board, and are found thus:—

If the angle is given, and under 45° , it will be found at the top, but from 45° to 90° it will be at the bottom; and when the degrees exceed 90 take its supplement, that is, what the angle wants of 180 , and if a Sine, Tangent or Secant, take the Sine, Tangent and Secant. Suppose you want the Sine of $20^\circ 20'$,—look at the top of Table XXV, and abreast of $20'$ in the col. marked M the Log. Sine is— 9.540931 . Suppose the Sine of $120^\circ 20'$, subtract from $180.00 = 59.40$ and Sine from the bottom of the page, and miles at the right side stand Sine $= 9.936062$. Another method is,—take 90° from the angle, and take Co-Sine for Sine, Co-Secant for Secant, and Co-Tangent for Tangent. As in the above case, take 90 from 120.20 it leaves 30.20 , and Co-Sine is 9.936062 . But if the angle to seconds be required, take the diff. abreast of the Log. given to miles, multiply by the seconds and cut off two figures to the right and add to the given Log. If the angle $30^\circ 20' 20''$ to find Log.,—the Log. given for $30^\circ 20'$ is 9.936062 , the diff. is 123 multiplied ($\times$) by the 20 , equal ($=$) to 2460 , by cutting off the two figures to the right it leaves 24 or 25 to be added ($+$) to 936062 , gives the Log. 9.936087 . But if a Co-Sine, Co-Secant or Co-Tangent be given, subtract the diff. Co-Sine

required of $40^{\circ} 40' 40''$. Corresponding Log. to $40^{\circ} 40'$ is 9.879963, diff. $181 \times 40 = 7240$, sub. gives 9.879891. It will be remembered when the figures cut off are less than 50 they are to be rejected, but greater ones are to be added. A few examples will show when they are to be added or rejected.

EXAMPLES.

$$\begin{array}{r} \text{Find Log. Sine } 35^{\circ} 45' 55'' = 9.766598 \quad 292 \text{ diff.} \\ \quad \quad \quad + 161. \quad \quad \times 55 \\ \hline \end{array}$$

$$\text{Ans. } 9.766759 \quad \cdot 160, 60$$

The two figures cut off exceed 50, one more is added.

$$\begin{array}{r} \text{Find Log. Co-Sine } 25^{\circ} 35' 45'' = 9.955186 \quad 101 \text{ diff.} \\ \quad \quad \quad - 45. \quad \quad \times 45 \\ \hline \end{array}$$

$$\text{Ans. } 9.955141 \quad \cdot 505$$

$$\cdot 404$$

$$\cdot 45/45$$

The two figures cut off, less than 50, are rejected.

THE LOG. GIVEN TO FIND THE ARC.

If a Sine, Secant or Tangent be given, seek in the Tables, and if it be found to agree, there will be no seconds, but if not, take the next less Log., also the diff. between it and the given Log., to that diff. annex two cyphers, and divide by the diff. found in col. marked Diff., and the quotient will give the seconds required. But if a Co-Sine, Co-Secant or Co-Tangent be given, take the next greater Log. and annex the seconds found to the degrees and minutes.

$$\begin{array}{l} \text{Find the Arc corresponding to Log. Sine } 9.452078 \\ \text{next less, } 452060 \end{array}$$

$$\begin{array}{r} \text{Diff. } 713)1800(02 \\ \quad 1436 \\ \hline \end{array}$$

$$\text{Diff. } 364$$

The next less log gives $16^{\circ} 27'$ and by annexing what is found in the quotient 02, or 3 nearly, we have the answer, $16^{\circ} 27' 04''$.

Find Arc of Co-Sine 9.975233. This is found to agree exactly in the col., and the Arc corresponding is $19^{\circ} 10'$.

Find Arc of Co-Secant 0.110525
next greater, 0.110626

Ans. $50^{\circ} 49' 59''$.

171)1010(59 seconds.

855

1550

1539

11

All Degrees less than 45° will be found at top of page, and miles found in left hand col.; but all over 45° at the bottom, and miles in right hand page.

EXAMPLES FOR PRACTICE.

Log. Sine,	$5^{\circ} 11' 00''$	Ans. 8.955894.
“ “	5 11 44	“ 8.956913.
“ Co-Sine,	76 20 00	“ 9.373414.
“ “	76 20 35	“ 9.373111.
“ Secant,	17 25 00	“ 0.020382.
“ “	17 25 25	“ 0.020398.
“ Co-Secant,	72 29 00	“ 0.020620.
“ “	72 29 29	“ 0.020611.
“ Tangent,	9 25 00	“ 9.219710.
“ “	9 25 45	“ 9.220296.
“ Co-Tangent,	68 49 00	“ 9.588316.
“ “	68 49 09	“ 9.588260.

LOG. GIVEN TO FIND ARC.

Sine,	9.763067	Ans. $35^{\circ} 25' 00''$
Co-Sine,	9.765726	“ 54 19 58.
Secant,	0.764940	“ 80 06 33, nearly.
Co-Secant,	0.402222	“ 23 19 59.
Tangent,	9.817850	“ 33 19 20, nearly.
Co-Tangent,	8.411639	“ 88 31 19.

PARALLEL SAILING.

If a ship sails on a parallel of Lat. she will of course be making all diff. of Long., and if you sail on a parallel of Lat. within five degrees of the Equator, the distance run, or the departure will be the diff. of Long. But the more you sail toward

the N. or S. the miles of Long. become less, for in Lat. 60° the degree of Long. is only 30 miles, and will decrease in proportion as you approach the Poles, at which points it becomes nothing. The rule is very simple and will be found thus:—Take the Secant of the Lat. Table XXIV (rejecting 10 of index) and common Log. Table XXIV of departure (or distance run), add both and their sum found in Table XXIV will give the dist. in Nat. number col.

EXAMPLES.

In Lat. 60° , Secant, (XXV) 0.301030
Departure 120, Log. (XXIV) 2.079181

Diff. Long. 240. 2.380211

In Lat. $10^\circ 30'$ Secant, 0.007334
Departure 140, Log. 2.146128

Diff. Long. 142.4 2.153462

In Lat. $78^\circ 35'$, Secant, 0.703461
Departure 999, Log. 2.999565

Diff. Long. 5046.9 3.703026
702947 next less Log.

86)790 (^{Diff.}₉)
774

In Lat. $30^\circ 30'$ N., and Long. $177^\circ 20'$ W., sailed 420 due West,—What is the Long. in?

Secant of Lat. $30^\circ 30' = 0.064680$
Log. of Dept. 420 $= 2.623249$

Diff. Long. $= 6)487.4 = 2.687929$

8.7 W.

Long. Diff. 177.20 W.

185.27

Exceeds opposite 360.00 Meridian, take from 360, and changes
from W. to E. Longitude.

174.33 E.

QUESTIONS FOR PRACTICE.

In Lat. $47^{\circ} 47'$ and depart. 333.	Ans. 495.6
In Lat. 22 22 and depart. 22.2.	" 240.1
In Lat. 11 11 and depart. 1.11.	" 1.131
In Lat. 77 27 and depart. 777.	" 2576
In Lat. 52 00 and Long. $2^{\circ} 10' E.$, departure made to the East 80.1 :- Required the Long. in.	
	Ans. 00 00 00, or Mer. Greenwich.
In Lat. 60° and Long. 175 W., a ship sails due West 150 miles—What Long. is she then in?	
	Neither in E. or W., but 180 from Greenwich.

MERCATOR'S SAILING.

It is generally preferred to find the course from one Port or headland to another, and particularly when the dist. is large. The course and distance is found by the following rule:—Place one Lat. under the other and subtract the less from the greater, if both be N. or both be S.; but if one is N. and the other S., add them, which will give you the true diff. of Lat. in degrees and miles; then multiply the degrees by 60 and take in the miles,—it will then be all miles. Next take each Lat. at the top of Table 3 (meridonal parts), and the miles in the side col., and in the angle will be found the meridional diff. (which are all miles) and add or subtract, as was done with both Latitudes. Next find the diff. of Longitude, and if they are of same name, take their difference, but if of contrary names, their sum. If the degrees exceed 180 take that sum from 360° , and convert it into miles, as you did the Latitude.

When you get your diff. of Lat., be sure and name it either North or South, as the case may be, and do the same with the Long., for a great many mistakes arise through such neglect. A few examples will suffice to show how they are named.

A ship in N. Lat., and decreasing her Lat., the course will be South; but increasing, will be North,—the same in South Lat. Likewise with Long.,—if you are in West Long. and decreasing, the course is E.; if increasing, the course is West. It often occurs that you change from one Long. into another,—that is

crossing the opposite Meridian (180),—you still will be steering the same course.

Then put down the diff. Long. and add 10 to the index, and under it put the Mer. diff. of Lat. and subtract. That will give the Tangent course in Table XXV, and abreast will be found Secant, and that added to Log. of diff. Lat., Table XXIV, will give the distance.

Ex.—A ship in Long. $178^{\circ} 20'$ E., sails to $176^{\circ} 20'$ W., although she changes her Long., she does not change her course, she will be still steering E., and would until she returned to the same place that she left.

EXAMPLES.

Ship from Lat. $40^{\circ} 40'$ N., and Long. $44^{\circ} 44'$ W., sails until she arrives at Lat. $55^{\circ} 55'$ N., and Long. $56^{\circ} 56'$ W.—What is her course and dist.?

	Meridional parts.	
Lat. A. $40^{\circ} 40'$ N.	2675	Long. A. $44^{\circ} 44'$ W.
Lat. B. $55^{\circ} 55'$ N.	4065	56 56 W.
15 15	1390	12 12
60		60
915 N.		732 W.
Diff. Long. 732 2+10	12 864511	Secant course=0 053129
M. parts, 1390	3 143015	L. of diff. Lat. 915, 2 961442
Tang.		
course N. 27 46 W. = 9 721497		Dist. 1027 = 3 014571

In the above example the ship sails from a low to a high N., and from a low to a high W., therefore the course is N. and W., she increases both.

Lat. A. $26^{\circ} 26'$ N.	1645	Long. A. $35^{\circ} 35'$ W.
Lat. B. $15^{\circ} 15'$ N.	926	Long. B. $25^{\circ} 25'$ W.
11 11	716	10 10
60		60
671 S.		610 E.
Diff. Long. 610 2+10	12 785330	Sec. course, 0 118523
Mer. parts. 716	2 854913	L. of diff. Lat. 671, 2 826723
Tang. course S. 40 26 E. = 9 930427		
		Dist. 881.5 = 2 945246

Lat. A. $36^{\circ} 36'$ S.	2363	Long. A. $137^{\circ} 37'$ E.
Lat. B. $38^{\circ} 38'$ N.	2517	Long. B. $156^{\circ} 56'$ W.

<u>75 14</u>	<u>4880</u>	<u>294 33</u>
60		360 00
		<u>65 27</u>
		60

3927 E.

D. Long. $3927^{\circ} 2 + 13^{\circ} 13' = 394061$ Secant course, 0 108376
M. parts. 4880 3 688420 Long. Dif. Lat. $4514, 3^{\circ} 654562$
Tang.

course N. $38^{\circ} 49'$ E. =. 9 905641 Dist. $5793 = 3^{\circ} 762938$

In this example the ship sailed from S. to N. Lat. and crossed the Equator, and as she had to run the $36^{\circ} 36'$ miles of South-
ing to reach the Equator, and $38^{\circ} 38'$ of Northing, both Lats.
must be added. She also sailed from one Long. into another
and crossed the opposite Meridian, therefore, both Longs. must
be added; and each Long. being greater than 180° , it must be
subtracted from 360° before it is reduced to miles.

N. B.—It must be remembered that 10 must be added to the
index of the difference of Long. in all cases.

EXAMPLES FOR PRACTICE.

In the following examples the course and dist. is required.

Lat. A. $3^{\circ} 33'$ N. Long. A. $4^{\circ} 44'$ E.
Lat. B. $4^{\circ} 44'$ S. Long. B. $5^{\circ} 55'$ W.
Ans.—S. $45^{\circ} 00'$ W. Dist., 100.4.

Lat. A. $5^{\circ} 55'$ S. Long. A. $9^{\circ} 29'$ W.
Lat. B. $6^{\circ} 26'$ N. Long. B. $19^{\circ} 19'$ E.
Ans. N. $86^{\circ} 59' 30''$ E. Dist., 590.7.

Required, the course and dist. from Cape Sable in Lat.
 $43^{\circ} 23'$ N., and Long. $65^{\circ} 37'$ W., to Cape Clear, Ireland, Lat.
 $51^{\circ} 26'$ N., Long. $9^{\circ} 29'$ W.

Ans.—N. $77^{\circ} 56'$ E. Dist., 2310 miles.

Required, course and dist. from Cape Sable, Lat. $43^{\circ} 23'$ N.,
Long. $65^{\circ} 37'$ W., to Cape of Good Hope, in Lat. $33^{\circ} 54'$ S.,
and Long. $18^{\circ} 24'$ E.

Ans.—Course S. $44^{\circ} 49'$ E. Dist., 6357.

Required, course and dist. from Halifax, Lat. $44^{\circ} 26'$ N.,

Long. $63^{\circ} 34' W.$, to Monte Video, in Lat. $34^{\circ} 53' S.$, and Long. $56^{\circ} 15' W.$

Ans.—Course, S. $4^{\circ} 43' E.$ Dist., 4772.

TIDES.--HOME PORTS.

In all the Ports of Great Britain and the West of Europe, as far as Gibraltar, and to the Cattagat in the North Sea, the Tides can be easily found, as there are several Ports of Reference, or Standard, and in these Ports they are known every day in the year by means of a Tidal Gauge. But as there are about two hundred intermediate Ports, or harbors, that have no Tidal Gauge, and as it is often necessary to ascertain the Tides in all these Ports, there are Constants given in the Admiralty Tide Tables, from page 103 to 108, which are to be added or subtracted as marked abreast of the Port sought. Constant is the number of hours and minutes that elapse between the time of high water at the Standard Port and the Port you are looking for. When Constant is added (+) the Tide will be later in the day; but if subtracted (—) the Tide will be earlier. For instance,—You wish to know what time it will be high water at Dorchester, (Bay of Fundy); St. John would be the Port of Reference, as the Tide is known there every day, and it is high water full and change days at 11h. 21m. Now, as the flood tide runs nearly E., and Dorchester being to the eastward, the Constant is +, and the Tide must necessarily be later in the day at Dorchester than at St. John. Again, you wish to ascertain what time it will be high water at Quoddy Head on a certain day. The flood Tide runs by Quoddy in an easterly direction towards St. John, and the time which elapses is about 45 minutes, therefore that 45 minutes is the Constant to be — from high water at St. John, and consequently the high Water at Quoddy Head will answer 45 minutes before the St. John high water. I think the young Mariner will easily discern how the Constants are to be applied, and by referring to the above explanations will have very little trouble in finding the time of high water on any day at any of the Home Ports.

THE CONSTANTS, AND HOW TO APPLY THEM TO THE MORNING (A. M.) AND EVENING (P. M.) TIDES FOUND IN THE TIDE TABLES.

If Constant is add. (+)—found in pages 103 to 108—add to

the time found in the calendar of the month and day, and it will give the A. M. and P. M. Tides respectively ; but when Constant is added to A. M. Tide and it exceeds 12 hours, it will give the P. M. Tide by taking 12 hours from it ; then you must take the evening's Tide before, and if it exceeds twelve hours you will have a morning Tide, but if not, you will only have a P. M. Tide that day.

When Constant is subtracted (—) and is less than the Tides given, it will give the two Tides that day ; but if — and a blank marked thus — occurs in the A. M. column, take the P. M. Tide and subtract, and if the subtraction can be made without borrowing 12 hours, there will be one P. M. Tide that day ; but if you have to borrow twelve hours it will give the A. M. Tide, and then take the next morning tide and borrow 12 hours and that will give the P. M., but if you can make a subtraction without borrowing 12 hours, there will be only an A. M. and no P. M. Tide that day. Whenever the Constant is — and exceeds the A. M. Tide in the calendar, that Tide must be rejected, and use the P. M. Tide instead, and if necessary, 12 hours must be borrowed, the same as if a blank (—) occurred.

The following examples will better illustrate to the pupil how to employ the Constants. (Tide Table for 1873 used.)

Ex.—Suppose you wish to know what time high water will occur at Dartmouth on April 1st, 1873. Look in Tide Table, page 107, and you will see Dartmouth, and abreast stands Constant—0h. 33m., and in right col. under Standard Ports will stand Davenport,—that will be the Port of Reference for Dartmouth ; next look in calendar for April, and find Davenport, and in the morning col. stands 8h. 4m., and in afternoon col. stands 8h. 21m. Now by add. (+) Constant 0h. 33m. to both Tides, it will give 8h. 37m. for morning, and 8h. 54m. for afternoon Tide.

Find the time of high water at Ballycotton, April 8, 1873. Waterford is Port of Reference, and Constant is sub. (—), 0h. 26m., and in col. for April and under Waterford is 2h. 11m. forenoon, and 2h. 42m. afternoon, and Constant — 0h. 26m. gives 1h. 45m. A. M., and 2h. 16m., P. M.

EXAMPLES.

Find time of high water A. M. and P. M. at Cherbourg on May 4th.

Brest, Port of Reference,		^{h.} 8 ^{m.} 52 A. M.	^{h.} 9 ^{m.} 32 P. M.
Const. +		4 02	4 02
P. M. of 3rd,		^{h.} 12 ^{m.} 54 P. M.	^{h.} 1 ^{m.} 34 P. M., 5th
		4 2	no use.
00 11 A. M. 4th day.		00 54	

It will be seen by the above Tides that by + Constant to A. M. Tide it exceeds 12 hours, and makes it a P. M. Tide,—and by + to P. M. Tide, it makes it A. M. Tide of 5th day,—so the Tide of the evening of the 3rd had to be used, and Constant add. (+) to it exceeded 12 hours, and made an A. M. Tide of 4th day.

Find A. M. and P. M. Tides at Exmouth, May 20th.

Davenport, Port of Reference.		A. M. 11 41	P. M. of 19th.
		+ 38	^{h.} 11 ^{m.} 00
		00 19 P. M.	38
			11 38
			no use.

Only a P. M. Tide on the 20th, as Constant + to P. M. Tide of previous P. M. Tide does not exceed 12 hours.

Find time of high water A. M and P. M., at Baltimore, Ireland, on May 6th. Queenstown Port of Reference.

A. M. — P. M.		^{h.} 0 ^{m.} 30.	A. M. 7th ^{h.} 1 ^{m.} 04.
Const. —		38.	38.
A. M. 11 52.			26. 7th day.
			no use.

When Constant is — as above, and the subtraction can be made without borrowing 12 hours from the following Tides, there will only be one Tide that day. It will also be seen that the A. M. Tide is within 8 minutes of noon, and as a general thing there must elapse about 12 hours and 25 minutes between each consecutive Tide.

Find time of high water at Cromarty on June 24th.

Leith, Port of Reference.		^{h.} 1 ^{m.} 40	^{h.} 2 ^{m.} 01
		Const. —	2 21

A. M. 11 40 no P. M.

In the above Tide the Constant is greater than the A. M. Tide, therefore it must be rejected, and the afternoon Tide used instead, and as a subtraction could not be made, 12 hours had to be borrowed, which made it a forenoon Tide; and as the Constant could be subtracted from the following morning Tide without borrowing 12 hours, there is only an A. M. Tide that day.

Find the A. M. and P. M. Tides at the following Ports :—

			A. M.	P. M.
Jan. 8th.	Ballycotton (Ireland),	Ans. No.	0	22
Feb. 5th.	Bristol (England),	" 00 02	00	30
Mar. 30th.	Port Patrick (Scotland),	" No.	00	18
April 5th.	Llanelly (Wales),	" 11 34	No.	
May 4th.	Ballycastle Bay (Ireland),	" Noon.		
June 11th.	Ordforness (England),	" 11 15	11	35
July 27th.	Douglass (Isle of Man),	" 00 19	00	49
Aug. 3rd.	Tanera (Summer Isles),	" 11 39	No.	
Sept. 1st.	Alderney (Cinq Isles)	" No.	00	37

It may not be amiss to state here that when a blank (—) occurs in the A. M. col. and Const. is sub. (—) if a subtraction can be made from the P. M. col., there will be only a P. M. Tide that day. Also, if Const. + and — in P. M. col., if the sum of Const. and A. M. Tide does not exceed 12 hours, there will be only an A. M. Tide that day.

TIDES.—FOREIGN PORTS.

In finding the time of high water for any Foreign Port the Constant is to be applied in the same manner as in the Home Ports. But you must first find a Const. by taking Brest as a Standard, and the time of high water on full and change days is 3h. 47m., and the difference between that and the full and change days of any other port that exceeds five degrees to the W. or E. is the Const. And to know when the Const. is + or — place full and change of Brest and the Port required; take their difference, and if Brest is the least, the Const. is +, but if greatest —. It is quite plain that if the full and change happen at St. John 11h. 21m., that of Brest 3h. 47m., the difference is 7h. 34m. That is, St. John Tide is later 7h. 34m. in the day than at Brest; therefore, by + 7h. 34m. to the time of high water found at Brest in the Admiralty Tide Tables, on any day, will give the time of high water at St. John. But as

the Moon has some influence over the water it requires another small correction, found thus: Take the diff. of Transit between the two days (found in left col., marked Moon's Transit, Tide Tables), and the Long. of the required Port in side col., in the angle of meeting will be a correction to be + in W. Long. and — in E. It may be remarked here, that as the Transit of the Moon is computed for the meridian of Greenwich, and as Brest is $4\frac{1}{2}$ degrees to the W. of Greenwich, it will cause a small error, which, however, can be avoided by + $4\frac{1}{2}$ degrees to all places in W. Long., and — in E.

The following examples will show more plainly to the learner how the corrections are to be applied.

Require the time of High Water at St. John, Long. 66° W., on Jan. 30th, 1873.

Standard, Brest	^{h.} ^{m.} 3 47.	High Water at Brest 30th.	
St. John	11 21.	^{h.} ^{m.} A. M. 4 50.	^{h.} ^{m.} P. M. 5 10. No use.
Const. +	7 34.	Const. + 7 34.	4 30 Evening 29th.
		00 24.	7 34
		Cor. + 00 10.	00 04
			00 10
		P. M. 00 34.	
		A.M. 00 14	

Transit 30th,	^{h.} ^{m.} 1 50.	Long. 66°
" 31st,	2 42.	$4\frac{1}{2}$

Cor. 0 52. Table XVI, Norie. $70\frac{1}{2}$

Constant + to A. M. exceeds 12 hours, makes a P. M. Tide. The preceding Tide of 29th must be taken, and as it exceeds 12 hours it gives a morning Tide.

June 1st, 1873.—Require the A. M. and P. M. Tides at Trincomalie (Ceylon).

Brest,	^{h.} ^{m.} 3 47	High water at Brest, June 1st,	^{h.} ^{m.} 7 30 A. M.
Trincomalie,	8 18	Const. + 4 31	
Const. +	4 31		12 01
		Cor. —	10
Transit, June 1st,	5 13		
" May 31st,	4 27		11 51 A. M.

Cor. — 46 Table XVI, Norie.

In the preceding Tide the Const. added to the Brest Tide exceeds 12 hours, but as the cor. reduced it to 11h. 51m. it makes an A. M. of it, and it being only 9' from noon, there can be no other Tide that day.

August 1st, 1873.—Require the A. M. and P. M. Tides at Halifax, N. S., Long. 63 W.

Brest,	^{h.} 3 ^{m.} 47	High water at Brest, Aug. 1st,	^{h.} 8 ^{m.} 24
Halifax,	^{h.} 7 ^{m.} 49	Const. +	^{h.} 4 ^{m.} 02
Const. +	^{h.} 4 ^{m.} 02	Tide of July 31st,	^{h.} 8 ^{m.} 03
		Const. +	^{h.} 4 ^{m.} 02
		Cor. +	^{h.} 00 ^{m.} 26
			^{h.} 00 ^{m.} 05
		Cor. +	^{h.} 9
			^{h.} 00 ^{m.} 14
			A. M.

In working the last Tide, the Const. + to A. M. makes a P. M. Tide, and taking the previous evening and adding the Const., it exceeds 12h., or crosses over midnight, therefore it gives an A. M. Tide.

October 1st, 1873.—Require the A. M. and P. M. Tides, Kyau-chau Bay (Yellow Sea), Long. 120° E.

		High water at Brest, Oct 1st,	^{h.} 10 ^{m.} 57
			+ ^{h.} 1 ^{m.} 13
Brest,	^{h.} 3 ^{m.} 47		^{h.} 12 ^{m.} 10
Kyau-chau,	^{h.} 5 ^{m.} 00		^{h.} — ^{m.} 19
Const. +	^{h.} 1 ^{m.} 13	A. M.	^{h.} 11 ^{m.} 51
			no P. M.

In the last question, the Const. being + to the A. M. Tide at Brest, it exceeds 12h. and makes it a P. M. Tide; but cor. for Long. E. 19' when subtracted brought it back to A. M. Tide, and being so near there can be no P. M. Tide that day.

QUESTIONS FOR PRACTICE.

Required the A. M., and P. M. Tides at the following Ports :—

	1873.		A. M.	P. M.
Feb.	28.	St. John, N. B., Long. 66° W.	Ans. No.	0 19
May	22.	Pei-ho, Long. 122° E.	" No.	13
Dec.	19.	Parsboro, N. S., Long., 65° W.	" No.	5
Sept.	2.	Hakodadi, Japan, Long. 135° E.	" No.	3
Nov.	23.	Yarmouth, N. S., Long. 66° W.	" 11 50	No.
Oct.	12.	N. York, U. S. Long. 74° W.	" No.	10

DAY'S WORK.

What is called a day's work is the course or courses, the diff. of Lat. and departure, and finally to ascertain the true course and dist., the Lat. and Long. in, and her true position at noon. Each course a vessel sails on is subject to two corrections, and sometimes to three. The first two are variation and deviation; the former is caused by the magnetism of the earth, the latter by the iron used in the construction of the ship, and these two are to be used when a ship is sailing before the wind, or the wind right after her; but when she is hauled by the wind, or the wind on either side, she is then making lee-way, and that must be allowed on each course with the variation and deviation. I think it would be out of place to state here the amount of lee-way caused by the different sails, the speed the ship has through the water, and the nature of the sea at the time,—for of these a careful Master or Mate will soon judge by several means when at sea; and as lee-way will be in its proper place in all the examples in this work, there is no need of further remarks.

HOW TO CORRECT COURSES.

All courses must be reckoned from the N. towards the E. and W., and from the S. towards the E. and W.: that is,—the points, or degrees, increase from nothing up to 8 points, or 90 degrees. Easterly variation and deviation are always allowed to the right, Westerly to the left, and lee-way is allowed opposite to the wind.

Suppose a ship's course N. N. E., wind N. W., variation $1\frac{3}{4}$ E., deviation $\frac{1}{4}$ E.,—What would be her true course?

N. N. E., or N. 2 E.

Var. + $1\frac{3}{4}$ E. allowed to the right hand.

3 $\frac{3}{4}$

Dev. + $\frac{1}{4}$ E. to right, also.

4 0

Lee-way, 0 0 going free.

—

True course, N. 4 0 E., or N. E.

The course is N. 2 points E., and as it increases towards the

E. by var. and dev. added, both being Easterly, makes the course N. E. or N. 4 E.

Compass course N. N. E., wind E. by N., lee-way $\frac{1}{2}$, dev. $\frac{3}{4}$ E., var. $2\frac{1}{4}$ E.

N. N. E., or N. 2 E.

Lee-way — $\frac{1}{2}$

$1\frac{1}{2}$

Dev. + $\frac{3}{4}$

$2\frac{1}{4}$

Var. + $2\frac{1}{4}$

N. E. $\frac{1}{2}$ E. $4\frac{1}{2}$

In this example the lee-way is subtracted, as she is on the starboard tack and drifting towards the N., and lessens the points, but the dev. and var. are added, as both being E., therefore, true course N. $4\frac{1}{2}$ E.

Compass course N. W. by W. $\frac{1}{2}$ W., wind N., lee-way $1\frac{1}{2}$, dev. $1\frac{3}{4}$ W., var. $2\frac{1}{2}$ W.

Co. N. $5\frac{3}{4}$ W.

Lee-way + $1\frac{1}{2}$

7

Dev. + $1\frac{3}{4}$

$8\frac{3}{4}$

Var. + $2\frac{1}{4}$

11

16

In this ex. the ship is steering between N. and W., and the wind from the N., the lee-way is towards the W.; also dev. and var. being W. is allowed to the left, and all three added puts her out of N. into the angle of S. and W., and when the course exceeds 8 pts., sub. from 16. (See form of work.)

S. W. by W., or S. 5 W. 5

Compass course S. $\frac{1}{2}$ E., wind E. by S., lee-way $1\frac{1}{2}$, var. $1\frac{1}{4}$ W., dev. $1\frac{3}{4}$ W.

Co. S. $\frac{1}{2}$ E.

$1\frac{1}{2}$

S. 1 W., — 1

Var. — $1\frac{1}{4}$

S. $\frac{1}{4}$ E., $\frac{1}{4}$

+ $1\frac{3}{4}$

S. 2 E., or S. S. E., 2

In this ex. the course is S. $\frac{1}{2}$ E., or $\frac{1}{2}$ left of S., lee-way to right, the lesser is subtracted from the greater, and changes the angle from S. E. to S. W., var. being W., allowed to left, changes the angle to S. E., and dev. +, being W. gives the course as below.

N. B.—The learner should never forget, that all courses

which cross over N. or S., the lesser must be — from the greater ; but over E. or W. must be +, and then — from 180 if in degrees,—if in points, from 16.

Compass course W. S. W., wind S., lee-way $2\frac{1}{4}$, dev. $2\frac{3}{4}$ W., var. 3 E.

Co. W. S. W. or S. 6 W.

Lee-way + $2\frac{1}{4}$

$8\frac{1}{4}$

Dev. — $2\frac{3}{4}$

$5\frac{1}{2}$

Var. + 3

— $8\frac{1}{2}$

16

This angle is to the N. and W., but the dev. being W., it is — and changes back to S. and W. without being subtracted from 16; and as variation is + it changes again to N. and W., and being over 8 — 16.

W. $\frac{1}{2}$ N., or N $7\frac{1}{2}$ W. $7\frac{1}{2}$

The next page will show the Traverse Table as kept at sea, all courses by compass corrected, the diff. of Lat. and departure for each course, and Tables 1 and 2 explained.

DAY'S WORK.

H.	K.	10ths.	Courses.	Wind.	Lee-way.	Dev.	Remarks.
1	4	4	N.	E. N. E.	$2\frac{1}{4}$	$1\frac{1}{4}$ W.	Departure taken at noon from a point of land in Lat. $42^{\circ} 30'$ N., and Long. $74^{\circ} 20'$ W. Bearing by compass S. S. W., dist. 10 miles.
2	4	4					
3	4	4					
4	4	4					
5	5	2	N. E.	E. S. E.	$2\frac{3}{4}$	$1\frac{1}{2}$ W.	
6	5	2					
7	5	2					
8	5	2					
9	3	6	E.	S. S. E.	2	$1\frac{3}{4}$ W.	
10	3	6					
11	3	6					
12	3	6					
1	6	6	S. E.	E. N. E.	0	$1\frac{1}{4}$ E.	Dev. as per Log.
2	6	6					
3	6	6					
4	6	6					
5	3	3	S. S. E.	S. W.	$1\frac{1}{4}$	1 E.	Var. $3\frac{3}{4}$ E.
6	3	3					
7	3	3					
8	3	3					
9	4	4	S. W.	S. by E.	$2\frac{1}{4}$	$1\frac{3}{4}$ E.	Current setting S. S. E. (cor. Mag.) $1\frac{1}{2}$ miles per hour for the whole day.
10	4	4					
11	4	4					
12	4	4					

1st course, N. 0

Lee-way + $2\frac{1}{4}$ left or N. $2\frac{1}{4}$ W.Dev. + $1\frac{1}{4}$ left.

	—	$3\frac{1}{2}$
Var.		$3\frac{3}{4}$

True course N. $\frac{1}{4}$ E. $\frac{1}{4}$ right of N.

In this course her head is N., the wind E. N. E., or on her right side, so she is on the starboard tack, and $2\frac{1}{4}$ pts. lee-way

drives her to the W. Dev. being W. is also added, and increases more to the W.; but the var. being E., and allowed to right, must be subtracted. Now, as the var. is more than the lee-way, and dev. $3\frac{1}{2}$ pts. places her to the left of N., the lesser must be subtracted from the greater, which places her to the right of N., hence N. $\frac{1}{4}$ E. is true course.

2nd course. N. 4 E. or 4 R. of N.

Lee-way, — $2\frac{3}{4}$ left.

— $1\frac{1}{4}$
Dev. $1\frac{1}{2}$ left.

— $\frac{1}{4}$
 $3\frac{3}{4}$ right.

True course, N. $3\frac{1}{2}$ E. $3\frac{1}{2}$ right of N.

This course crosses over N. twice, and each time the lesser has to be subtracted from the greater. Her head being 4 points R. of N., dev. and lee-way combined make $4\frac{1}{4}$, that is, $\frac{1}{4}$ point to L. of N., or N. $\frac{1}{4}$ W., and var. being R. $3\frac{3}{4}$, the $\frac{1}{4}$ pt. must be subtracted, and changes from the N. W. angle to N. E.

3rd course. E. or 8

Lee-way — 2

— 6
Dev. — $1\frac{3}{4}$

— $4\frac{1}{4}$
Var. + $3\frac{3}{4}$

—
True course E. 8

The ship's head is E., the wind S. S. E., so she is on the star-board tack, and lee-way is subtracted from 8 pts., leaving 6 pts. to R. of N. Dev. is subtracted also, it being to the L., or W., gives $4\frac{1}{4}$ pts.; but var. being E. is allowed to R. and added to $4\frac{1}{4}$ makes the true course N. 8 pts. E., or E.

4th course, S. 4 E.

Lee-way — $1\frac{1}{4}$

—
Dev. — $2\frac{3}{4}$

Var. — $3\frac{3}{4}$

—
True course S. 1 W. 1

In this course her head is S. 4 pts. E., wind E. N. E., she is making no lee-way; the dev. being $1\frac{1}{4}$ E. is subtracted, as also is the var., but as the var. is greater than the course, the lesser must be subtracted from greater, and crosses from the

S. E. angle to the S. W.

5th course S. 2 E. Her head is S. 2 E., wind S. W.,
 Lee-way + $1\frac{1}{4}$ she is on the starboard tack,
 — and lee-way $1\frac{1}{4}$ is added, but
 $3\frac{1}{4}$ dev. being E. and allowed to
 Dev. — 1 R. is subtracted, also the var.,
 — and as in the last course, the
 — $2\frac{1}{4}$ lesser must be subtracted from
 Var. $3\frac{3}{4}$ the greater, in crossing North
 — or South.

True course S. $1\frac{1}{2}$ W. $1\frac{1}{2}$

6th course S. 4 W. In this course she is heading
 Lee-way + $2\frac{1}{4}$ S. W., the wind is S. by E.,—
 — she is on the port tack, and
 $6\frac{1}{4}$ the lee-way is added, being
 Dev. + $1\frac{3}{4}$ opposite to the wind, also the
 — dev. and var.; all combined
 8 put the course across W., and
 Var. — $3\frac{3}{4}$ as it exceeds 8 pts., must be
 — subtracted from 16, which
 — $11\frac{3}{4}$ changes it from S. W. angle
 16 to N. W.

True course N. $\frac{1}{4}$ W. $4\frac{1}{4}$

Depart. course S. S. W., opposite pt. N. N. E. N. 2 E.

The opposite pt., is always taken Dev. — $1\frac{1}{4}$
 for a dep. course, and dev. is gener-
 ally given as for the first course,
 and variation allowed, as on all Var. + $3\frac{3}{4}$
 other courses.

True course, N. $4\frac{1}{2}$ E. $4\frac{1}{2}$

Current course S. 2 E. Nothing but var. is allowed on
 $3\frac{3}{4}$ the current courses, as the
 — dev. is allowed on each course
 True course S. $1\frac{1}{2}$ W. $1\frac{1}{2}$ during the whole 24 hours.

TAKING COURSES AND DISTANCES FROM TABLE I.

Enter the Table with the course at the top (if under 4 pts.)
 and dist. from left hand col. abreast will be the diff. of Lat.
 and dep. in the first two cols.; but if the course exceeds 4 pts.
 it must be taken from the bottom of page, when Lat. becomes
 dep. and dep. Lat.; if there are miles and tenths in the dist.,

they must be taken out as if they were whole numbers, and make the last figure of the whole number a decimal; if there are tenths in the col., and they are above 5, one (1) must be added to the tenth that is pointed off. For instance: find Lat. and dep. corresponding to $20^{\circ}6'$, the course $2\frac{1}{2}$ pts. Look in Table 1, page 10, in one of the cols. marked "dist.," until you find 206, and in the next cols. of diff. of Lat. and dep.,—in Lat. col. stands $181^{\circ}7'$, and in dep. col. $97^{\circ}1'$; now, by pointing off the last figure of each they will stand thus,— $18^{\circ}1'$, $9^{\circ}7'$; and as the figure pointed off from diff. Lat. is 1, one more is added for the 7 tenths, it being over 5, and would be placed in the Traverse Table $18^{\circ}2'$ Lat., $9^{\circ}7'$ dep., nothing being added to dep., as the tenth in the col. is under 5. Again, if you wish to find the diff. of Lat. and dep. for $33^{\circ}8'$. This cannot be taken out as above, as the Tables give only as high as 300° . It is found thus,—under $2\frac{1}{2}$ pts., at top and find in dist.col. $38'$, and in two next cols. of Lat. and dep. is $29^{\circ}1'$ Lat., $15^{\circ}6'$ dep., next take the 8 tenths in a dist. col. also, and in Lat. is $07^{\circ}1'$, and in dep. $03^{\circ}8'$. Now the miles found must be made tenths and added to the tenths of the $33'$, and if the figure that stands for tenths is over 5, 1 tenth more is to be added to the tenths already found.

	Lat.	Dep.
First found,	$29^{\circ}1'$	$15^{\circ}6'$
Second found,	7	4
Proper diff.	$29^{\circ}8'$	$16^{\circ}0'$

The 8 tenths in dep. is over 5, and 1 more is added to the 3, which makes it four. Whenever the course is taken from the top, the greatest is to be placed in the N. or S. cols.; but when found at the bottom, the greatest must be placed in the W. or E. cols. When all the courses and dists. are taken out and placed in their proper cols., as will be seen in the annexed form, all are to be added up, and the lesser Lat. taken from the greater, also, the lesser dep. taken from the greater, and named after the Lat. and dep. which are the greatest. If the most is in the N. and E. cols., the course will be N. and E.; but if in S. and W., the course will be S. and W.

TO FIND THE COURSE AND DISTANCE.

Seek in Table 1 until Lat. and dep. are found to agree (or nearly), and the course will be found at the top if Lat. is most,

but at bottom if dep. is most, and the dist. will be found in the dist. col. at left hand.

TO FIND THE LAT. AND LONG.

With the diff. of Lat. found placed under the Lat. left, add if of same name, but sub. if of contrary names, and that will give the Lat. in; then add both Lats. and divide by 2, which will give mid Lat.; then find the mid Lat. at top of Table 1, if it is under 4 pts. or 45° , but at the bottom if over 4 pts. or 45° ; then find the dep. in Lat. col., and in the dist. col. will stand diff. of Long.,—if it exceeds 60 miles divide by 6 and it will be in degrees, place it under the Long. left, and if of same name add, but if of different names sub., and it will give the Long. in.

The above is finding the diff. of Long. by mid Lat., and as it is sufficiently correct in short distances such as Day's Work, no notice will be taken of any other method here.

The learner must remember, that if a ship be near the Equator in N. Lat., and the diff. of Lat. made S. will exceed the Lat. left; the Lat. left must be sub. from the diff. of Lat., and the remainder will be named S.

The same precaution is necessary in passing the meridian of Greenwich or Long. 0; but in passing from one Long. into another at the opposite meridian, or 180° , both must be added, and the sum taken from 360° , and named after the latter.

Ex. 1st.—A ship is in Long. $179^\circ 10'$ W., and sails due W. 140 miles = $2^\circ 20' + 179^\circ 10' = 181^\circ 30' - 360^\circ = 178^\circ 30'$ E.

Ex. 2nd.—A ship is in Long. $0^\circ 40'$ W. and sails $49'$ E.,—What Long. will she be in? $0^\circ 40' - 0^\circ 49' = 9'$ E. The ship crosses over the first meridian, and as the dist. made E. exceeded the Long. left, the lesser is taken from the greater, and named E. after the latter.

It would benefit the learner to fill in the blank spaces in the following Table with a dash or cross, previous to entering the Traverse Table. For instance,—in the first course she is making N. and E., and nothing in S. and W. cols., &c.

	Dist.	Diff. Lat.		Departure.	
		N.	S.	E.	W.
True Courses,					
N. $\frac{1}{4}$ E.	17·6	17·6	—	9·	—
N. $3\frac{1}{2}$ E.	20·8	16·1	—	13·2	—
E.	14·4	—	—	14·	—
S. 1 W.	26·4	—	25·9	—	5·2
S. $1\frac{1}{2}$ W.	13·2	—	12·6	—	3·8
S. $4\frac{1}{4}$ W.	9·6	—	6·5	—	7·1
N. $4\frac{1}{2}$ E.	10·	6·3	—	7·7	—
S. $1\frac{3}{4}$ W.	36·	—	33·9	—	12·1
		50·0	78·9	43·9	28·2
			50·0	28·2	
Diff. Lat. and Dep.			28·9	15·7	

Gives course S. $2\frac{1}{2}$ E., dist. 32'.

Lat. left, $42^{\circ} 30'$ Diff. of Lat. 28·9 = 29 S., and is —
 Lat. in, 42 1 N. from the Lat. left, being of different
 names.

2)84 31

Mid Lat., 42 15 Found in Table 2 gives diff. Long.

For dep., 15·7 = 21' E. The diff. Long. is also of a
 Long left, $74^{\circ} 20$ W. different name to Long.
 left, therefore subtracted.
 Long in, 73 59 W.

This is the only Day's Work that will be in pts., and the learner will easily comprehend by the explanations given how to use it practically at sea. I have made it my study to treat all questions practically, without superfluities, for the benefit of the young mariner, so that they may be readily understood and more easily mastered. Moreover, as it is intended only for those that are preparing to pass an examination in Canada, and as they are to work all in degrees, it would only be lost time for the pupil to go through different Day's Work in pts., the changes of courses, etc., etc.

H.	Courses.	K.	10ths.	Winds.	Lee-way.	Dev.	Remarks.
1	N. 24 W.	4	2	W.	12	1·15 E.	A point of land in Lat. $31^{\circ} 25'$ N., Long. $9^{\circ} 29'$ W. Bearing by compass N. $22^{\circ} 30'$ E., dist. 12 miles.
2		4	2				
3		4	3				
4		4	3				
5	N. 45 W.	5	2	N. 24 E.	5	4·20 W.	
6		5	3				
7		5	3				
8		5	2				
9	N. 67 W.	3	4	N.	4	15·30 W.	Dev. as per Log.
10		3	4				
11		3	4				
12		3	8				
1	S. 22 W.	8	3	N. 67 W.	0	2 E	Var. $25^{\circ} 30'$ W.
2		8	3				
3		8	3				
4		8	3				
5	S. 45 W.	7	5	N. 70 W.	5	5 E.	
6		7	5				
7		7	2				
8		7	2				
9	S. 67 W.	3	4	S. 5 W.	15	3 E.	Current (cor. mag.) S. 15° E., 25 miles in the 24 hours.
10		3	4				
11		3	4				
12		3	4				

S. 22 30 W. dep. course.
+ 1 15 E. dev. R.

— 23 45
25 00 var. L.

S. 1 15 E. true course.

N. 22 00 W. 1st course.
— 12 00 Lee-way R.

10 00
— 1 15 dev. L.

8 45
+ 25 30 var. L.

N. 34 15 W. true course.

N. 45 00 W. 2nd course.
+ 5 00 Lee-way L.

50 00
+ 4 20 dev. L.

54 20
+ 25 30 var. L.

N. 79 50 W. true course.

N. 67 00 W. 3rd course.
+ 4 00 Lee-way L.

71 00
+ 15 30 dev. L.

86 30
+ 25 30 var. L.

— 112 00 exceeds 90°.
180 00

S. 68 00 W. true course.

S. 22 00 W. 4th course.
+ 2 00 Lee-way R.

— 24 00
25 30 var. L.

S. 1 30 E. true course.

S. 45 00 W. 5th course.
— 5 00 Lee-way L.

40 00
+ 5 00 dev. L.

45 00
— 25 30 var. L.

S. 19 30 W. true course.

S. 67 00 W. 6th course.
15 00 Lee-way R.

82 00
+ 3 00 dev. R.

85 00
— 25 30 var. L.

S. 59 30 W. true course.

S. 15 00 E. current course.
+ 25 30 var. L.

S. 40 30 E. true course.

NORTHERN AFFAIRS
& NATIONAL RESOURCES

DEC 10 1975

Northern Affairs

Courses.	Dist.	N.	S.	E.	W.
S. 2° E.	12	—	12	4	—
N. 34 W.	17	14 1	—	—	9 5
N. 80 W.	21	3 6	—	—	20 7
S. 68 W.	26	—	9 7	—	24 1
S. 2 E.	33·2	—	33 2	1 2	—
S. 20 W.	29·4	—	27 4	—	10
S. 60 W.	13·6	—	6 8	—	11 8
S. 41 E.	25	—	18 9	16 4	—
		17 7	108 00	18 0	76 1
		— 17 7		Dep. 58 1	
		6)9,0 3			

Diff. Lat. — 1 30 S.

Lat. left, 51 25 N.

Lat. in, 49 55 N.

2)101 20

Mid. Lat. 50 40

Diff. Long. 93 = 1 33 W.

Long. left, 9 29 W.

Long. in, 11 02 W.

It has already been remarked that previous to entering the Traverse Table to take out the diff. of Lat. and dep. for each course, it would be well to fill up the vacant spaces with a dash as above. In the first course she is making Southing and Easting, and the diff. of Lat. goes in the S. and E. cols. and nothing in the N. and W.

There are numerous mistakes made by putting the Lat. and dep. in the wrong cols., especially when in a hurry, and the attention is drawn to the cols., in the Epitome; but by a strict observance of the above method a mistake cannot be made.

The diff. of Lat. 90° 3 and dep. 58·1 is found to agree in Table 2, at top of page at 33°, and as diff. of Lat. is S., and dep.

W., the course will be S. 33° W.; in the adjoining dist. col. is found 108 miles, which is the distance made good. By adding the Lat. in and Lat. left, and dividing by 2 the middle Lat. is found, and that taken as a course; and dep. in a Lat. col. will give diff. of Long. in a distance col.

H.	Courses.	K.	10ths.	Winds.	Lee-way.	Dev.	Remarks.
1	S. 2·49 E.	9	3	S. 60 E.	2·50	3 W.	A point of land in Lat. 40° 20' N., Long. 74° 40' W. Bearing by compass N. 22° 30' W. dist. 15 miles.
2		9	6				
3		8	3				
4		5	5				
5	S. 70 E.	5	7	N. 40 E.	4	14 W.	
6		5	7				
7		5	6				
8		5	7				
9	N. 25 W.	6	4	N. 45 E.	20	4 E.	Dev. as per Log.
10		6	4				
11		7	6				
12		7	5				
1	N. 61 W.	7	4	N.	15	19 E.	Var. 16 W.
2		8	3				
3		6	6				
4		5	5				
5	S. 70 W.	4	4	N. 42 W.	25	14 E.	Current (cor. mag.) S. 23 W. Dist. 12 miles during the 24 hours.
6		4	7				
7		4	7				
8		3	9				
9	N. 30 E.	3	9	N. 40 W.		10 W.	
10		3	8				
11		3	6				
12		3	5				

Corrected Courses.

S. 42° E.
S. 19 E.
N. 84 E.
N. 57 W.
N. 73 W.
S. 43 W.
N. 4 E.
S. 7 W.

Diff Lat. 26⁵/₅.
Dep. 20⁴/₄.
True Course, S. 36° 30.
Dist. 33¹/₁.
Lat. in, 39° 53 N.
Long. in, 75° 06' W.

H.	Courses.	K.	lots.	Winds.	Lee-way.	Dev.	Remarks.
1	S.	9	8	S. 67 E.	0	1.45 W.	A point of land in Lat. $43^{\circ} 30'$ N. Long. $66^{\circ} 20'$ W. Bearing by compass N. $45^{\circ} 30'$ E. dist. 12 miles.
2		9	8				
3		9	8				
4		9	6				
5	S 56 15 W	8	7	N. 57 W.	20	10.15 W.	
6		8	7				
7		8	3				
8		8	3				
9	S. 45 W.	7	6	N. 67 W.	14	7.30 W.	Dev. as per Log.
10		7	6				
11		6	4				
12		5	4				
1	N 67 30 W	4	8	S. 46 W.	12	7.15 W.	Var. 14° W.
2		4	7				
3		4	3				
4		4	2				
5	S 67 30 W	3	6	S. 12 E.	3	8.45 W.	
6		3	6				
7		3	4				
8		3	4				
9	N 78 45 W	2	8	S. 67 E.	0	12 W.	Current (cor. mag.) S. 45° W. 10 miles during the 24 hours.
10		2	8				
11		2	8				
12		2	6				

Corrected Courses.

Dep. S. 30° W. Dist. 12 miles.1st. S. 16° E. " 39 "2d. S. 12° W. " 34 "3d. S. 10° W. " 27 "4th. N. 77° W. " 18 "5th. S. 48° W. " 14 "6th. S. 75° W. " 11 "Cur. S. 31° W. " 10 "Diff. Lat. $124^{\circ} 6'$, Dep. $50^{\circ} 8'$.True course, S. 22° W.

Dist. 135 miles.

Lat. in, $41^{\circ} 25'$ N.Long. in, $67^{\circ} 29'$ W.

TO CONVERT TIME INTO LONGITUDE.

The circumference of the earth is 360° , and the sun makes that circuit in 24 hours, and by dividing 360° by 24 it gives

15°, so the sun travels at the rate of 15° per hour. If we wish to know what Longitude corresponds with any number of hours, minutes and seconds, we multiply the hours by 60 and divide the sum by 4.

1st Ex.—	2d Ex.—	3d Ex.—
^{h.} 1 time.	^{h.} 2 time.	^{h. m. s.} 4 24 8 time.
× 60	× 60	× 60
—	—	—
÷ 4)60	÷ 4)120	÷ 4)264·8
—	—	—
15° Long.	30 Long.	66·2 Long.

In the last example the hours are multiplied by 60, the minutes brought in or added, the seconds brought down, and the whole divided by 4 gives the Longitude, 66° 2', which is the Longitude of St. John; so when it is noon in St. John, it will be twenty-four minutes and eight seconds past 4 o'clock at London, or the meridian of Greenwich.

Another method is, to multiply the hours by 3 and by 5.

1st Ex.—	2d Ex.—	3d. Ex.—
1	2	4 24 8
× 3	× 3	× 3
—	—	—
3	6	13 12 24
× 5	5	5
—	—	—
15 Long.	30 Long.	66 2 0 Long. (same as above.)

TO CONVERT LONGITUDE INTO TIME.

Multiply the seconds, minutes and hours by 4, and divide the product by 60.

1st Ex.—	2d Ex.—	3d Ex.—
15	30	66·2
× 4	× 4	× 4
—	—	—
÷ 6, 0)6, 0	÷ 6, 0)12, 0	÷ 6, 0)26, 4 8
—	—	—
1·0 time.	2 time.	4 24·8 time.

In dividing by 60 one figure is cut off, which makes it Short Division (no quotient), and the figure cut off is minutes; if there is a remainder after dividing by 6, 0 it is placed before the figure cut off, and the seconds will remain the same.

BY SECOND METHOD.

$\begin{array}{r} 1\text{st Ex. } \div 3)15^{\circ} \\ \hline \div 5)5 \\ \hline 1 \text{ time.} \end{array}$	$\begin{array}{r} 2\text{d Ex. } \div 3)30^{\circ} \\ \hline \div 5)10 \\ \hline 2 \text{ time.} \end{array}$	$\begin{array}{r} 3\text{d Ex. } \div 3)66 \ 2 \ 9 \\ \hline \div 5)22 \ 00 \ 40 \\ \hline 4 \ 24\cdot8 \text{ time.} \end{array}$
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GREENWICH DATE.

As Greenwich date is required to work all problems in Nautical Astronomy, and as all the elements of the heavenly bodies are given for Apparent and Mean noon at the meridian of Greenwich, they are given in the Nautical Almanac for every day in the year.

But the navigator has a different meridian every day, and must necessarily compute the change between the meridian of Greenwich and his meridian; therefore, he must ascertain what time it is noon at Greenwich, or, what is termed the "Greenwich date." It is found thus:—Convert the Longitude into time, and if West, add to the time at ship; but if East Longitude, subtract, and it will give the Greenwich date. But if Civil Time be kept, and it is morning, or A. M., at ship, 12 hours must be added before applying the Longitude, for the Civil day begins at midnight, and the Greenwich, or Astronomical day at noon; therefore, 8 hours in the morning, Civil day, will be 20 hours Greenwich, or Astronomical day.

It should be remembered that when 12 hours are added to the A. M. Civil time it changes the day one less, as Greenwich day begins 12 hours before the Civil day is ended.

All the elements used in this work are for the year 1876, with the exception of the Tides, as a copy of them cannot be had yet.

EXAMPLES.

January 1st, at 3h. 30m., P. M., in the Long. of Cape Clear, $9^{\circ} 29' \text{ W.}$, required the Greenwich date.

$\begin{array}{r} \text{Time, 3h. 20m.} \\ + \quad 37 \ 56 \\ \hline \end{array}$	$\begin{array}{r} \text{Long } 9^{\circ} 29' \text{ W.} \\ \quad 4 \\ \hline \end{array}$
$\text{Greenwich Time} = 3 \ 57 \ 56$	$37 \ 56 \text{ in time.}$

February 2nd, at 8h. 20m., A. M., in the Long. of St. John, N. B., $66^{\circ} 2' 19'' \text{ W.}$, required the corresponding Greenwich time.

Civil time, Feb. 2nd., 8 20 A. M. Long. 66° 2'
12 . 4

Astronomical day, 1st, = $\begin{array}{r} 20\ 20 \\ 4\ 24\ 8 \\ \hline 24\ 44\ 8 \\ 24 \end{array}$ $\begin{array}{r} 6,0)26,4\ 8 \\ \hline 4\ 24\ 8 \text{ in time.} \end{array}$

Greenwich date, Feb. 2d, = 44 8

By adding 12 hours to the Civil time it changes the day one less, but Long. W. added exceeds 24 hours, and changes it back again to the 2nd day, so it will be 44^h 8s. past noon at Greenwich.

March 4th.—When the sun is on the meridian in Long. in $66^{\circ} 2' \text{ W.}$, what is the time at Greenwich?

$ \begin{array}{r} \text{Noon,} = \begin{array}{ccc} \text{h.} & \text{m.} & \text{s.} \\ 00 & 00 & 00 \\ + & 4 & 24 & 8 \\ \hline \end{array} \\ \text{G. Date, 4th,} = 4 \quad 24 \quad 8 \end{array} $	$ \begin{array}{r} \text{Long. } 66 \quad 2 \\ \times \quad 4 \\ \hline \div 6, 0) 26, 4 \quad 8 \\ \hline 4 \quad 24 \quad 8 \text{ in time.} \end{array} $
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April 8th.—In Long. $120^{\circ} 20'$ E., when the sun was on the meridian what was the time at Greenwich?

Noon, 8th, 00 00 00	Long. 120 20 E.
— 8 1 20	× 4
G. Date, 7th, = 15 58 40	÷ 6/0)48/1 20
	8 1 20 in time.

May 10th.—At 8h. 20m. A. M., in Long. $130^{\circ} 40'$ E., what is the time at Greenwich?

	Time, 8 20 00	Long. 130° 40' E.
	+ 12	× 4
Astronomical date, 9th, =	20 20 00	÷ 6, 0) 52, 2 40
	— 8 42 40	
		8 42 40 in time.
G. date, 9th, =	11 37 20	

In the two last examples you are in East Longitude, and as the sun will be seen there 8h. 42m. 40s. before it will at Greenwich, the Long. must be subtracted to give Greenwich time.

June 20th.—At 3.45 P. M., in Long. $59^{\circ} 20'$ E., what is the corresponding Greenwich time ?

	h.	m.	s.		
Time, 20th,	3	45	00	Long. $59^{\circ} 20'$	
+	24				4
19th,	27	45	00	6,0)	23, 7 20
—	3	57	20		
G. date, 19th, =	23	47	40		3 57 20

In this example the Long. turned into time exceeds the hours of P. M. time at the ship, 24 hours must be added to the ship's time, and change the day from the 20th to the 19th.

All questions similar to this puzzles the beginner, and I am often asked,—Why, that by adding 24 hours to the given time at ship it don't make it a day more, instead of a day less? The beginner, by carefully examining the above question, can see that if he losses a day, he will gain in the hours; for there cannot be 27h. 45m. in a day, and as his Long. is E., and exceeds the time at ship, 24 hours have to be added to enable him to make a subtraction.

TO CORRECT THE SUN'S DECLINATION.

The sun's Declination is what is N. or S. of the Equator, and is given in the Nautical Almanac for every day in the year, for (Ap.) apparent and (M. T.) mean noon at the meridian of Greenwich. But as the mariner changes his meridian every day, and seldom, if ever, on the meridian of Greenwich, he ought to be able to calculate the change of Declination between that given in the Nautical Almanac and his time, whether in W. or E. Long.

There will be only one rule given here, and that is by "hourly difference" and middle time. Middle time is the difference of the hourly change of decl. at noon of one day, and at noon of the next day, and will be found to agree, nearly, with any of the other methods, and more accurate than some.

RULE.

Take out of the Nautical Almanac the decl. from page 1st for App. time, and from page 2nd for M. T.; also, the hourly diff. Multiply the hourly diff. by the hours and parts of an hour that

you are to the W. or E. of Greenwich, and if the decl. is increasing, add,—but if decreasing, subtract from the decl. taken out, and you will have the correct decl. for the ship's time.

In finding the parts of an hour (or decimal), divide the seconds by 6, place the minutes before the result and divide by 6 also, and that will be the decimal required.

What part of an hour is 24m. 30s. ?

$$6)30s.$$

$$6)245$$

·41 parts, or decimal.

In 2m. 48s. what part of an hour ?

$$6)48s.$$

$$6)28$$

·5 (nearly.)

In 50m. 50s. what part of an hour ?

$$6)50s.$$

$$6)508$$

·85 (nearly.)

In 28m. 3s. what part of an hour ?

$$6)3s.$$

$$6)280$$

·47

In fact it will be near enough to divide the minutes by 6 and reject the seconds altogether.

EXAMPLES.

1876, Jan. 1st.—In Long. $9^{\circ} 29' W.$, when the sun is on the meridian what is the correct decl. A. T. ?

Decl., page 1.,	23 2 36	H. D.,	12 ⁿ ·05	Long. $9^{\circ} 29' W.$
	— 8		·63	4
Cor. Decl. S.,	23 2 28		3615	37 56 in time.
			7230	
			7,5915	6)379
				·63 pts. of an hr.

In this ex. there is no necessity for taking middle time, as it is only $\cdot 63$ of an hour from Greenwich noon, and the change of Decl. only 12s, so by multiplying the H. D. by the decimal found, and cutting off 4 figures, as there is a decimal of 2 figures in the H. D., and 2 decimals in the time, which leaves 7,5915—8s. nearly, to be subtracted, because the decl. is decreasing.

1876, Feb. 1st.—When the sun is on the meridian in a place the Long. of which is $88^{\circ} 58' \text{ E.}$, required cor. decl.

Decl. page 1st.,	17 11 42	H. D. 42 ^s .48	Long. $88^{\circ} 58'$
—	412	5.93	4
Cor. Decl.	17 7 30	12744	6)35, 5, 52
		38232	
		21240	5 55 52
		6)25, 1.9064	6)559
		4.12 (nearly).	.93 pts.

In this question the Long. turned into time is 5h. 55m. 52s., so the H. D. 42.48s. is multiplied by the hours and decimal of an hour, that is, of 55m. 52s., = .93, and after cutting off the 4 decimal figures there will yet remain three, which are seconds, then by cutting off 1 figure, and the remaining 25 divided by 6, will be minutes,—which must be subtracted as the decl. is decreasing, and we have the cor. decl. for the ship's place.

1876, March 19th.—At 7h. 20m. P. M. In Long. $174^{\circ} 48' \text{ W.}$, what will be the Decl.

Time at ship,	7 ^{h.} 20 ^{m.}	Long. $174^{\circ} 48'$
Long. M. time +	11 39 12 W.	4
G. Date, =	18 59 12	6)69, 9 12
		11 39 12
Decl. page 1st, 19th,	$0^{\circ} 17' 49''$	H. D., 59 ^s .27
	18 46	19
	57	53343
		5927
		6)112, 6, 13
		18 46

The middle time is neglected in this question, as it is .3 only between both noons, and as the cor. is greater than the decl. the decl. is subtracted from the cor. and changes decl. from S. to N.

1876.—April 11th, at 8h. 25m., A. M., App. time, in Long. $115^{\circ} 50'$ E., what will be the sun's decl. ?

Decl. 10th, $8^{\circ} 11' 2''$ H. D. $55^{\circ} 19'$ 10th noon. Long. $115^{\circ} 50'$ E.
 $54^{\circ} 84'$ 11th “ 4

2)11·03

6)46.3 20

55·01 mid. diff.

7 40 20 in time.

Time at ship, $8^{\text{h.}} 25^{\text{m.}} 00^{\text{s.}}$
 $+ 12$

10th, $30^{\text{h.}} 25^{\text{m.}} 00^{\text{s.}}$
 $- 7 43 20$

G. date 10th, = $12 21 40$

6)217

12·36

$\times 55·01$

1236

6180

6180

6)67.9 236

Increasing $+ 11 19$ or 20

Decl. 11th, $8 11 2$

Cor. decl. = $8 22 21$

Being A. M., at ship, 12 hours is added to reduce it to Astronomical time, and the Long. in time subtracted, it being E., gives Greenwich time, 12h. 21m. 40s., on the 10th. Then the seconds and minutes divided by 6, we have 12h. 36m., which is multiplied by mid. diff., 55·01s., gives 11m. 19s., or 20 cor. to be added to decl.

QUESTIONS FOR EXERCISES.

1876.—Jan. 10th, in Long. $40^{\circ} 40\text{m.}$ W., when the sun is on the meridian, what is the cor. decl. ?

Ans. $11^{\circ} 59\text{m. } 57\text{s. S.}$

1876.—Feb. 20th, in Long. $120^{\circ} 30\text{m. E.}$, when the sun is on the meridian, what is the cor. decl. ? Ans. $11^{\circ} 9\text{m. } 25\text{s. S.}$

1876.—March 21st, at 8h. 20m., P. M., Long. 140°W. , required the sun's cor. decl. Ans. $00^{\circ} 47\text{m. } 1\text{s. N.}$

1876.—Dec. 20th, at 8h. 40m., A. M., Long. $178^{\circ} 50\text{m. E.}$, required the sun's cor. decl. ? Ans. $23^{\circ} 26\text{m. } 49\text{s. S.}$

TO FIND THE LATITUDE BY THE SUN'S MERIDIAN ALTITUDE.

First note the Altitude as read off the Sextant or Quadrant, and if it has an error apply it by the sign + or —.

Next find the altitude in Table IV, and abreast in the next col. to the right will stand the refraction, always subtraction.

Next, on same page, under Table V, will stand the dip., and is found by looking down the col. under height; and abreast, under dip. is the cor., always subtraction.

The next cor. is parallel Table VI, always addition, (a.)

Then take out of Nautical Almanac the Semi-diameter, page 2, and if lower limb (marked) L. L. or $\bigcirc$ it is added, but upper limb (marked) U. L. or $\bigcirc$ it is subtraction, and that will give the true altitude of the Sun's centre.

Subtract the true altitude from 90° and you will have the zenith dist., to be named opposite to the bearing of the sun. That is, if the sun is to the N. when the observation was taken, the zenith dist. is called S. But if it bears S. from you it is named N.

Next place the Sun's cor. decl. under the zenith dist., and if of same name add, but if contrary names subtract, and you have the latitude called after the name of the greater. State the question as below:

1876, Jan. 20th.—In Long. $120^{\circ} 30' \text{E.}$, the obs'd alt. $\bigcirc$ bearing S. was $30^{\circ} 30' 30''$, index cor.— $1' 20''$, height of eye 21 feet. Required the Latitude.

(a.) The Refraction and Parallax together may be taken out from Table XVIII., Norie.

Obs'd alt.	30° 30' 30''	Sun's decl. 19th, 20 24 39.
Cor. —	1 20	Cor. for 16th, — 8 28.
	30 29 10	Sun's cor. decl. = 20 16 11.
Ref. IV,	— 1 37	
		H. diff. 19th, 31·27.
	30 27 33	“ “ 20=32·23.
Dip. V,	— 4 23	
		2)63·50.
	30 23 10	
Parl.VI, +	8	Mid. diff. 31·75.
	30 23 18	Long. 120° 30' E.
Semidr. +	16 17	4
True alt.,	30 39 35	6)48/2 00
	90 00 00	
		— 8 2 00
Zen. dist.	59 20 25 N.	24 00 00
Sun's decl.	20 16 11 S.	
		Gr. date 19th, 15 58 00
Lat.	39 4 14 N.	

Mid. diff. 31·75
 G. date, × 16 hours, nearly.

$$\begin{array}{r}
 19050 \\
 3175 \\
 \hline
 6/0)50,8,00 \\
 \hline
 8\cdot28
 \end{array}$$

N. B.—Greenwich date will be employed in all the questions in this work.

May 15th.—In Long. 66° 40' W., obs'd alt. $\odot$ bearing S. was 40° 40' 40'', cor. + 2' 20'', height of eye 14 feet, required the Lat.

Alt.	40 40 40	Decl. 16th, 19° 1' 2''	H. diff. 3494
Cor.	+ 2 20	Incr. + 2 33	3414
	<u>40 43 00</u>	<u>19 03 35</u>	<u>2)6908</u>
Ref.	— 1 8		
	<u>40 41 52</u>	Long. 66° 20'	Mid. diff. 34·54
Dip.	— 3 36	<u>4</u>	<u>4·42</u>
	<u>40 38 16</u>	6)26, 5 20	6908
Par.	+ 7		13816
	<u>40 58 23</u>	G. date, 40 25 20	<u>13816</u>
Semidr. +	15 41	<u>6)253</u>	<u>6)15, 2, 6668</u>
	<u>90 00 00</u>	<u>·42</u>	<u>2 32 or 33s</u>
True alt.	40 13 14		
	<u>90 00 00</u>		
Zen.	49 46 46 N.		
Dec.	+ 19 3 35 N.		

Lat. 68 50 21 N. Same name +.

1876, June 30th.—In Long. 74° 50' W., obs'd alt. $\ominus$ bearing N. was 33° 33' 33'', index cor. — 1' 20'', height of eye 22 feet, required the Lat.

Alt.	d. m. s. 33 33 33	Sun's decl. 30th, d. m. s. 23 9 16 N.	H. diff. s. 9·65
Cor.	— 1 20	Dec. cor. — 51	10·66
	<u>33 32 12</u>	Cor. decl. 23 8 25	<u>2)20·31</u>
Ref.	— 1 26		<u>10·15</u>
	<u>33 30 46</u>		nearly <u>5</u>
Dip	— 4 30		<u>50·75</u>
	<u>33 26 16</u>	Long. 74° 50' W.	
Par.	+ 8	<u>4</u>	
	<u>33 26 24</u>	6)29, 9 20	
Semidr. —	15 46	<u>4 59 20</u>	
True alt.	33 10 38		
	<u>90 00 00</u>		
Zen. dist.	56 49 22 S.	Different names.	
Decl.	— 23 8 25 N.		
Lat.	33 40 57 S.	Named after the greater.	

1876, April 3rd.—In Long. 44° W., obs'd alt. $\odot$ bearing N. was $74^{\circ} 50' 40''$, height of eye 20 feet, cor. — $2' 19''$, required the Lat.

Obs. alt.	d. m. s.	Decl.	d. m. s.	H. D.	s.	Long.	d.
	74 50 40		14 58 03		4561		44
Cor.	— 2 19	Cor. +	2 11		4498		4
	<u>74 48 21</u>	Cor. decl.	<u>15 00 14</u>		<u>2)9059</u>		<u>6)17/6</u>
Ref.	— 15						
	<u>74 48 6</u>			Mid. diff.	<u>45.29</u>		<u>2, 56</u>
					2.9		
Dep.	— 4 17				<u>40761</u>		<u>2.9</u>
	<u>74 43 49</u>				9058		
Par.	+ 2				<u>6)13,1,341</u>		
	<u>74 43 51</u>						
Semidr. +	15 54			Cor.	2.11		
	<u>74 59 45</u>						
	<u>90 00 00</u>						
Zen. dist.	15 00 15 S.						
Cor. decl.	15 00 14 N.						
	<u>00 00 1 S.</u>						
Lat.							

AMPLITUDE.

Amplitude is the bearing of any of the heavenly bodies when rising or setting, and is named E. in the morning, and W. in the evening. It is of great benefit to the navigator to correct any errors that may arise in his compass from the different cargoes taken on board, and also in sailing along coasts of a mineral nature. Every Master of a vessel, no matter whether off the coast or on it, should be able to detect an error in his compass by an Amplitude.

There is no necessity of an Azimuth compass to get the sun's mag. amplitude. It can be found correct enough by taking the compass on deck and placing any small bar, or even the parallel rule edge on the compass card and towards the centre of the sun, read off the bearing, and you have the sun's magnetic amplitude.

TO FIND THE TRUE AMPLITUDE.

The Secant of the Lat., rejecting 10 from index, and the Sine of the sun's cor. decl. added. The Sine corresponding to the sum will be the true amplitude, named E. if observed in the morning, and W. if observed in the evening, also after the sun's decl. That is, if the observation is made in the morning, and the decl. S., the amp. is E. and S., and in the evening W. and S.

TO FIND THE ERROR.

If the true and mag. amplitudes are of the same name, take their diff., but if of opposite names take their sums (that is. if one is N. and the other S.), and it will give the error.

TO NAME THE ERROR.

If the true amp. falls to the right of mag. amp., it is named E., but if to the left, it is named W. Suppose the sun's true amplitude was E. $20^{\circ} 30'$ S., and the mag. amp., or bearing by ship's compass, was E. $10^{\circ} 30'$ S., the true amp. is to the right, and the error would be called E. Or, fancy you are looking at both suns, point a hand at each (no matter whether morning or evening), and if the true sun is abreast of your right hand it will be E., but if to the left it will be W.

The error found is caused by local attraction,—that is, the iron that is used in building the ship; also, by iron cargoes taken on board,—both draw the needle of the compass either to the W. or to the E. from the N. point, and is named the Error.

But there is another error, called Variation, that affects the compass needle, which is caused by the magnetism of the earth, and acts different on the needle in different Latitudes, and sometimes it will be of the same name as the error (caused by local attraction) and different at other times, so both combined is called the Correct Deviation of the Compass.

TO FIND THE DEVIATION.

Having found the error, place under it the variation as given on the chart. Change name—If it be E. call it W., and if W., call it E.; then if they be of different names, take their diff. and name the Deviation after the greater; but if of the same name, add, and it will be the same name as both. Or, let the variation keep the same name, and if of different names, add.

but same name, subtract, and the difference, or sum (as the case may be) will be the Deviation.

Then, to name the Deviation, you must suppose yourself looking towards the N., and if the variation falls to the right of the error, the Deviation is to be named E., but if to the left of error, W.

N. B.—I would advise the learner to practice the first method (change names of var.), as he will have little or no trouble in naming the Deviation.

P. S.—When the sun's decl. is nothing, the true amplitude will be E. in the morning and W. in the evening. Also, if your Latitude is nothing, that is, you are on the Equator, the sun's correct decl. will be the true amplitude named after the decl., and when the error is nothing (00 00), that is, the true and magnetic amplitude are equal, the variation will be the deviation of an opposite name.

EXAMPLES.

1876, Jan. 1st.—At 4h. 20m. A. M., apparent time at ship, in Lat. $50^{\circ} 20'$ N. and Long. $150^{\circ} 10'$ W., the sun's magnetic amp. was E. $12^{\circ} 30'$ S. and var. $20^{\circ} 15'$ E., required the dev.

	^{h.} ^{m.} ^{s.}	^{d.} ^{m.} ^{s.}	^{s.}
App. time, 1st.	4 20 00	Decl. 23 2 36	Diff. 1205
	12 00 00	— 29	1320
Dec. 31st.,	16 20 00	Cor decl. 23 2 7	2)2525
	10 00 40		
	26 20 40	Long. $150^{\circ} 10'$	Mid diff. 1262
	24	4	23
		6,0)60,0 40	3786
G. Date, 1st.,	2 20 40	10 00 40	2524
			29,026

Lat. $50^{\circ} 20'$ Secant, 0.194961
 * Decl. 23 2 Sine, 9.592373

True amp. E. $37^{\circ} 48' 30''$ S. 9.787433
 Mag. amp. E. 12 30 S.

Error, 25 18 30 E. True, being to the right of mag.
 Var. 20 15 W. Change name of var.

Dev. 5 3 30 E. Named after the greater.

1876, Feb. 2nd.—At 6h. 30m. P. M., apparent time at ship, in Lat. $10^{\circ} 20' S.$, and Long. $176^{\circ} 50' E.$, sun's mag. amp. was $W. 30^{\circ} 20' S.$, and var. $7^{\circ} 10' W.$, required the dev.

App. time 2d.	^{h.} 6 ^{m.} 30 ^{s.}	Decl. 17 ^{d.} 11 ^{m.} 42 ^{s.}	Diff. ^{s.} 4248
	24	— 13 21	4322
	<u>30 30</u>	Cor. decl. 16 58 21	2)8,570
	11 47 20		<u>4285</u>
G. date, Jan. 1st.,	18 42 40		18.7
		Long. $176^{\circ} 50'$	29995
		4	34280
		<u>6)70,7 20</u>	4285
		Time, 11 47 20	6,0)80,1,295
			<u>13 21</u>

Lat. $10^{\circ} 20'$ Sect. 0.007102

Decl. 16 58 Sine, 9.465108

True amp. W., 17 15 30 S. 9.472210

Mag. amp. W., 30 20 00 S.

Error, 13 4 30 E. True, being to right of mag.

Var., 7 10 00 E. Change name of var.

Dev., 20 14 30 E.

1876, March 20th.—At 6.40 P. M., in Lat. $50^{\circ} 00m.$ and Long. $30^{\circ} 30m. E.$, the sun set by compass $W. 2^{\circ} 45m. N.$, and var. on chart $2^{\circ} 45m. W.$, required the dev.

Decl. 20th.	^{d.} 0 ^{m.} 5 ^{s.} 52	H. diff. ^{s.} 5924	Long. ^{d.} 30 ^{m.} 30 E.
	4 33	4.6	4
Cor. decl.	<u>0 1 19</u>	<u>35544</u>	<u>6)12.2 00</u>
		23696	
Civil time, 20th.	6 40		In time, 2 2
Long. in time, —	2 2	6,0)27,2,504	
G. date,	<u>4 38</u>	<u>4 32 3</u> nearly.	

Decl. 0	d. m. s. 1 19	Sine, 6.688665	True amp. W. 0	d. m. s. 2 45	N.
Lat. 50 00	Sect, 0.191933		Mag. amp. W. 0	2 45	N.
		9.780598	Error, 0	0	0
next less, —	764756		Var. +	2 49	0 E. (change name.)
Diff. ÷	34762)	158420(45//	Dev.	2 49	0 W.
		139048			
		193720			
		173810			

In the above example the decl. shows no degrees, but minutes and seconds, therefore it is necessary to find its value from the select pages at the beginning of Table XXV., as it gives the value of the nearest second; and as the diff. of the logs differed materially when the minutes were found, the next less has to be taken, and the difference divided by the diff. found in col. to find the seconds. It is not necessary to go into such close calculations in an amplitude, but the pupil should be acquainted with the Table.

1876, April 10th.—At 4h 30m. A. M., in Lat. $42^{\circ} 40m.$ N., and Long. $74^{\circ} 50m.$ W., the sun's mag. amp. was E. $4^{\circ} 25m.$ S., var. by chart $15^{\circ} 00m.$ E., required the dev.

Dec. 9th.	d. m. s. 7 48 54	Diff. ^s 5552	Long. d. m. 74 50
Inc. +	20 56	5519	4
Cor decl.	8 9 50	2)11071	6,0)29.9 20
		Mid. diff. 5535	M. time, 4 59 20
Civil time, 10th	h. 5 30	22.5	
	12	27675	
9th, 17 30		11170	
4 59 20		11170	
G. date, 9th.	22 29 20	6,0)125,6375	
		20 56	
	Decl. 8 10	Sine, 9.152451	
	Lat. 42 40	Sect. 0.133530	
True amp. E. $11^{\circ} 8 20$ N.		9.285981	
Mag. amp. S. 4 25 S.		285766	
Error,	15 33 20 W.	1069)2150(20	
	15	W. (change name)	2138
Dev.	30 33 20 W.		120 —

QUESTIONS FOR PRACTICE.

1876, May 20th.—At 7h. 30m. P. M., in Lat. $45^{\circ} 15m. N.$, and Long. $66^{\circ} 20m. W.$, the sun's mag. amp. was $W. 1^{\circ} 50m. N.$, var. by chart $10^{\circ} 20m. W.$, required the dev. of compass.
Ans. dev. $37^{\circ} 54m. E.$

1876, June 30th.—4h. 40m. A. M., in Lat. $48^{\circ} 40m. N.$, and Long. $50^{\circ} 30m. E.$, the sun's mag. amp. was $E. 30^{\circ} 20m. N.$, var. by chart $19^{\circ} 40m. E.$, required the dev. of compass.
Ans. dev. $25^{\circ} 55m. W.$

1876, July 5th.—At 8h. 15m. P. M., in Lat. $69^{\circ} 00m. N.$, and Long. $79^{\circ} 50m. E.$, the sun's mag. amp. was $W. 40^{\circ} 30m. S.$, var. by chart was $33^{\circ} 20m. E.$, required the dev. of compass.
Ans. dev. $13^{\circ} 21m. 30s. E.$

1876, Aug. 15th.—At 4h. 40m. A. M., in Lat. $00^{\circ} 00m. 00s.$, and Long. $28^{\circ} 10m. W.$, the sun's mag. amp. was $E. 3^{\circ} 40m. N.$, and var. by chart was $4^{\circ} 20m. W.$, required the dev. of compass.
Ans. $5^{\circ} 57m. W.$

1876, August 29th.—At 7h. 10m. P. M., in Lat. $45^{\circ} 15m. N.$, and Long. $66^{\circ} 20m. W.$, mag. amp. was $W. 4^{\circ} 15m. N.$, var. by chart $17^{\circ} W.$, required the dev. of compass.
Ans. $25^{\circ} 33m. 30s. E.$

1876, Sept. 23rd.—At 4h. 40m. A. M., in Lat. $50^{\circ} 30m. N.$, Long., $38^{\circ} 10m. W.$, mag. amp., was $S. 90^{\circ} E.$, var. $10^{\circ} 20m.$, $W.$, required dev. of compass.
Ans. $10^{\circ} 34m. 41s. E.$

1876, Oct. 1st., at 5h. 30m., P. M., in Lat., $45^{\circ} 40m. N.$, Long. $174^{\circ} E.$, mag. amp. was $W. 25^{\circ} 20m. S.$, var. $22^{\circ} 20m. W.$, required the dev. by compass.
Ans. $53^{\circ} 11m. 45s. E.$

1876, Nov. 20th.—At 5h. 30m. A. M., in Lat. $15^{\circ} 50m. S.$, Long. $27^{\circ} 00m. E.$, sun's mag. amp. was $S. 76^{\circ} 45m. E.$, var. by chart $4^{\circ} 20m. W.$, required the dev. of compass.
Ans. $11^{\circ} 40m. E.$

1876, Dec. 30th.—At 6h. 20m. P. M., Lat. $40^{\circ} 40m. N.$, Long. $70^{\circ} 00m. W.$, sun's mag. amp. $W. 10^{\circ} 20m.$, var. by chart $9^{\circ} 11m. W.$, required the dev. of compass.
Ans. $11^{\circ} 38m. W.$

TO FIND THE DAILY RATE OF A CHRONOMETER.

Every Master who trades to the West Indies, no matter how small his vessel, should be able to ascertain the daily rate of his Chronometer, both by the sea and an artificial horizon. There is no necessity for having an artificial horizon on board, as one can be made very simply,—by covering the head of a cask with molasses, or even with water, a true altitude can be found independent of the sea horizon. There are very few Ports in which a sea horizon is visible when lying at anchor. Very few Chronometers keep a uniform rate, and when Masters of vessels find that their Chronometers have lost or gained, and do not agree with the land they have made or the Port they are in, become uneasy, and perhaps may rate them by Chronometers of other vessels, for few, if any, like to send them ashore in the West Indies. The rate is found thus:—

If a Chrono. is fast }
and more fast, } gaining.

If fast }
and less fast, } losing.

If slow }
and more slow, } losing.

If slow }
and less slow, } gaining.

EXAMPLES.

If a Chrono. was fast of Greenwich Mean Time 4m. 3s. 4t. on Jan. 1st, and on Jan. 21st fast 5m. 58s. 3t., what would be the daily rate?

	m.	s.	t.
Fast, —	4	3	4
More fast,	5	58	3
	1	54	9
		60	
20)	114	9	(5s. 7t.
	100		gaining.
	149		
	140		
	9		

In this example the Chrono. is fast and more fast,—the diff. is taken, and divided by the interval, 20 days, which gives rate 5s. 7t., nearly. Whenever the remainder is less than half the divisor it is rejected, but if greater, one tenth is added to the quotient. If there be minutes in the diff. they must be brought into seconds before dividing by the days.

A Chrono. was slow 2m. 4s. 8t. on Feb. 10th, and Feb. 20th slow 2m. 8s. 8t., what is her daily rate?

$$\begin{array}{r}
 \text{m. s. t.} \\
 \text{Slow, } 2 \ 4 \ 8 \\
 \text{More slow, } 2 \ 8 \ 8 \\
 \hline
 10)40(.4\text{t., losing.} \\
 40
 \end{array}$$

On March 3rd, a Chrono. was fast 1h. 20m. 10s. 4t., and on March 23rd was fast 1h. 18m., required the daily rate.

$$\begin{array}{r}
 \text{h. m. s. t.} \\
 \text{Fast, } 1 \ 20 \ 10 \ 4 \\
 \text{Less fast, } 1 \ 18 \ 0 \ 0 \quad \text{Same name, subtract.} \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 2 \ 10 \ 4 \\
 60 \\
 \hline
 20)1304(6\text{s. 5t., losing.} \\
 120 \\
 \hline
 104 \\
 100 \\
 \hline
 4
 \end{array}$$

On April 30th, a Chrono. was fast 2h. 45m. 57s. 8t., and on May 17th was fast 2h. 45m. 12s. 9t., required the daily rate.

$$\begin{array}{r}
 \text{h. m. s. t.} \\
 \text{Slow, } 2 \ 45 \ 57 \ 8 \\
 \text{Less slow, } 2 \ 45 \ 12 \ 9 \\
 \hline
 17)44 \ 9(2.6. \quad \text{Gaining.} \\
 34 \\
 \hline
 1 \ 09 \\
 1 \ 02 \\
 \hline
 7
 \end{array}$$

On May 29th, a Chrono. was slow 22s. 4t., and on June 7th was slow 4s. 4t., required the daily rate.

$$\begin{array}{r}
 \text{s. t.} \\
 \text{Slow, } 22 \ 4 \\
 \text{Less slow, } 4 \ 4 \\
 \hline
 9)18 \ 0(2\text{s. Gaining.}
 \end{array}$$

June 20th, a Chrono. was fast 4m. 24s. 7t., and on June 30th was 4m. 27s. 7t. Required the daily rate.

m. s. t.
Fast, 4 24 7
More fast, 4 27 7

10)30(·3t. Gaining.

QUESTIONS FOR PRACTICE.

On July 10th, a Chrono. was slow 15m. 10s. 9t., and on July 22nd was slow 17m. 50s. 4t., required the daily rate.

Ans. 13·3. Losing.

August 29th, a Chrono. was fast 1m. 10s. 4t., and on Sept. 10th was fast 1m. 17s. 8t., required the daily rate.

Ans. 6·2. Gaining.

Sept. 21st, a Chrono. was slow 3h. 57m. 49s. 9t., and on Oct. 15th was slow 3h. 59m. 59s. 7t., required the daily rate.

Ans. 5·4. Losing.

On Nov. 29th, a Chrono. was fast 1h. 14m. 20s., and on Dec. 14th was fast 1h. 13m. 16s. 8t., required the daily rate.

Ans. 4·2. Losing.

TO FIND THE ACCUMULATED RATE.

The Accumulated Rate is what a Chronometer gains or loses in any number of days. The day that it is sent on board, the daily rate is given, and by multiplying the days and decimals of a day by the daily rate, it will give what is lost or gained in the interval.

Suppose you had a Chrono. on board from Jan. 27th to Feb. 21st., and at 8h. 20m. A. M., you wished to find the accumulated rate, the daily rate being 8s. 6t., gaining.

Civil Time, 21st., 8h. 20m.

+ 12

Interval from Jan. 27th

Astro. Time, 20th, 20

to Feb. 20th = 24d. 8h.

d.
Inter. 24 8 0
Daily rate, × 8·6
1488
1984
6, 0)21, 3, 28
Accum. date, 3 33

In this example the Chrono. gained 8s. 6t. per day, and the interval was 24 days and 20 hours; then you have to find what part of a day 20 hours is. By adding a cypher (0) to the 20 it makes it 200, and dividing that by 24 you find the decimal of a day.

Another method is to multiply by the days only, and take parts for the hours, divide into the daily rate. Thus:—

	Days, 24	Or thus, 24
12h. is $\frac{1}{2} \div$ daily rate, 8·6	8·6	12h. is $\frac{1}{2} \div$ 8·6
8h. is $\frac{1}{3}$	<u>14·4</u>	<u>14·4</u>
	192	192
	4·3	6 is $\frac{1}{2} \div$ 4·3
	2·8	2 is $\frac{1}{3} \div$ 2·1
	<u>6,0)21,3,5</u>	<u>7</u>
Same as above,	3 33 5	6,0)21,3,5
		<u>3 33 5</u>

N. B.—The first method is the most simple, and as the beginner often becomes confused in taking and dividing the parts of a day, as in the last, it is desirable that the first be used.

From noon, March 10th, until April 15th, at 4h. P. M., a Chrono. loses 2s. 9t. per day, what is the accumulated rate?

Interval, 36·2	2nd method, 36
2·9	4 is $\frac{1}{2} \div$ 2·9
<u>3258</u>	<u>324</u>
724	72
<u>6,0)10,4,98</u>	<u>5</u>
Acc. rate, 1 45 nearly.	6,0)10,4,9
	<u>1 45</u>

QUESTIONS FOR PRACTICE.

From May 30th until June 29th, at 4h. A. M., a Chronometer loses daily 4s. 2t. What is the accumulated rate.

Ans. 2m. 3s.

From August 29th until Sept. 4th, at 8h. P. M., a Chrono. gains 9s. 8t. What is the accumulated rate?

Ans. 1m. 2s.

From Sept. 5th until Dec. 29th, at 5h. A. M., a Chrono. loses daily 1s. 2t. What is the accumulated rate? Ans. 2m. 16s.

From Jan. 10, 1876, until Nov. 21st, at 9h. P. M., a Chrono. gains daily 8s. 4t. What is the accumulated rate?

Ans. 44m. 18s.

TO FIND THE GREENWICH DATE BY CHRONOMETER.

When a Chronometer is taken on board, it is seldom, if ever, on Greenwich Mean Time,—that is: to show the same hours, minutes and seconds as shown at the Royal Observatory at Mean noon. And what she is fast or slow is called the Original Error, which is to be added if slow, and subtracted if fast. Then the accumulated rate (as already shown) is to be applied and you have Mean Time at Greenwich. At the Dominion Board Examination the approximate Longitude is given, with the A. M. or P. M. hours at ship, to find the approximate Greenwich day. As no day is given by the Chronometer,—only hours, minutes, and seconds,—therefore to know whether it is A. M. or P. M. by Chronometer proceed thus: Set down the hours, minutes and seconds as given at ship, and if A. M., add 12 hours, and put the day one back; next, turn the Longitude into time, and if W. add to ship's time, but if E. subtract, and you have the Greenwich date nearly; if the Chronometer differs about 12 hours from the time found, 12 hours must be added to make both agree nearly. (Previous to 1872 the daily rate was given, but now the candidate has to find the daily rate in all examples given.)

1876, Jan. 29th.—At 8h. 20m., A. M., in Long. $63^{\circ} 30m.$ W., a Chrono. indicated 00h. 24m. 40s., which was slow 8m. 00s. 3t.: on Jan. 1st, and on Jan. 10th was slow 8m. 14s. 6t. Required the Greenwich date by Chronometer?

29th,	^{h. m.} 8 20	Slow,	^{m. s. t.} 8 00 3	Long.	63 30
	12		8 14 6		× 4
28th,	20 20	9)14 3	(1.6, ^{daily rate} losing.	6, 0)25, 4	00
	4 14		9		4 14 00
	24 34		53		
	24 00		54		
29th,	00 34	Interval from Jan. 10 to 29th, 19 ^{d.}			× 1.6 daily rate.
Chr.	^{h. m. s.} 00 24 40				
+	8 14 6 last rate,			114	
				19	
	32 54 6				
+	30 acc. rate.			30, 4	^{Acc. rate} Losing.
Gr. date, 29th,	33 24 6				

The Civil time was 8h. 20m., A. M., 12 hours had to be added to reckon from noon of the previous day, when the Astronomical day commenced, and had to be reduced a day less, from the 29th to the 28th; but Long. being W., and turned into time had to be added, and the sum exceeded 24 hours, 24 had to be subtracted which brought the day to the 29th again, and gave the Greenwich date nearly. The Chrono. indicated only a few minutes past noon, and the last rate (original) slow added, also acc. rate losing (slow and more slow) added, gave correct Greenwich date, agreeing nearly with approximate date.

1876, April 30th.—At 3h. 49m. P. M., in Long. $179^{\circ} 38'$ E., a Chronometer indicated 3h. 43m. 4s., which was slow 8m. 6s. Nov. 13th, 1875, and on Jan. 10th, 1876, was slow 6m. 33s. 8t. for Mean noon at Greenwich. Required the Greenwich date by Chronometer.

	h.	m.	s.		m.	s.	
30th,	3	49	00	First rate slow	8	6	Long. 179 38
	24	00	00	2d rate less "	6	33 8	4
29th,	27	49	00	Interval,	1	32 2	6.0)71,8 32
—	11	58	32 E.		60		
							11 58 32
App. G. date	29th	15	50 28		58)922	(1.6	gaining
					58		

	h.	m.	s.			
Chr.	3	43	4		31	342
+		6	33 8	last rate.	10	348
	3	49	37 8		21 Jan.	
		2	57		29 Feb.	
	3	52	34 8		31 March.	
	12	00	00 0		29 April.	
G. date, 29th,	15	52	35 8	×	110.7	Interval from 10th Jan. to 19th April.
					1.6	daily rate.
					664.2	
					1107	
					6,0)17,7,12	
					2 57	acc. rate.

In this question it was P. M. at ship, but A. M. at Greenwich.

because the ship's time was in advance of Chrono. 12 hours, nearly,—12 hours had to be added to Chrono. time to make it correspond with ship's date.

1876, June 14th.—At 8h. 30m., A. M., Longitude by acct. $38^{\circ} 50'$ E., a Chrono. indicated 6h. 00m. 58s., which was slow 6m. 00s. 1t. on April 19th, and on May 11th was slow 2m. 24s. 6t. for Greenwich Mean noon. Required the Greenwich date by Chrono.

14th, 8 30	slow, ^{m. s. t.} 6 00 1	April 19th.	Long. 38 50
12 00	less slow, 2 24 6	May 11th.	4
20 30	3 35 5	22 Inter.	6, 0)15, 5 20
— 2 35 20 E.	60		2 35 20
13th, 17 54 40	22)2159(9·8 gaining.		
	198		
	179	31	
	176	11	
		20 May.	
Chr. ^{h. m. s.} 6 00 58	3	13 June.	
+	2 24 6 original.	33·9	
	6 03 22 6	9·8	
—	5 32 acc. rate.	2712	
G. date, 5 57 50		3051	
12		6, 0)33, 2, 22	
G. date, 13th, 17 57 50		5 32	

In the above question it was A. M. at ship and A. M. at Greenwich, therefore 12 hours had to be added to both dates to reduce them to Astronomical time. The Original rate, slow, was added, but being slower than the first rate, the Acc. rate was gaining and had to be subtracted.

1876, Feb. 10th.—At 9h. 00m. A. M., Long. by acct. $8^{\circ} 50'$ W., a Chrono. indicated 10h. 21m. 59s., which was fast 34m. 40s. 9t. on Oct. 30th, 1875, and on Dec. 2nd, 1875, was fast 39m. 01s. 4t. for Mean noon at Greenwich. Required the Greenwich date by Chronometer.

10th 9 00	Fast, ^{m. s. t.} 34 40 9 Oct. 30	Long. 8° 50 W.
12	More fast, 39 1 4 Dec. 2	4
21 00	4 20 5	35 20
35 20	6	
9th, 21 35 20	33)250·5(7·9	31
	231	2
Chr. 10 21 59		29 Dec.
— 39 1 4	295	31 Jan.
9 42 57 6	297	9 Feb.
— 9 11	2	69·8
9 33 46 6		7·9
12		6282
		4886
G. date, 21 33 47		6)55, 1·42
		9 11

TO FIND THE HOUR ANGLE.

The Hour Angle is the Apparent time from noon when an observation is taken, and is named A. M. if taken in the morning, and P. M. if taken in the afternoon. It is found by adding the true Altitude, the ship's Latitude and the Polar distance, and the sum divided by 2 gives the half-sum; from the half-sum subtract the true altitude, which is called the remainder.

Then take the Co-Secant of the Polar distance,
 The Secant of the ship's Latitude,
 The Co-Sine of the half-sum,
 And the Sine of the remainder,

} Table XXV.

The sum of the four Logs (rejecting 10 from the index) found in Table XXXI will be the Apparent time from noon, or Hour Angle.

NOTE.—If the Lat. be 0, and the declination 0, the Zenith distance turned into time will be the Hour Angle.

The Polar distance is found by subtracting the correct

declination from 90, when of the same name, but adding it to 90 when of different names.

If the Polar distance is over 90, it must be subtracted from 180, as the Tables are given to 89 only. Or the Secant of the declination can be taken which will give the same result.

EXAMPLES.

The true alt., $17^{\circ} 46' 50''$ N., decl. $21^{\circ} 2' S.$, Lat. $28^{\circ} 45' N.$
Required the Hour Angle.

Alt., $17^{\circ} 46' 50''$	Decl. $21^{\circ} 2' \div 90 = 111^{\circ} 2' P. D.$	
Lat., $28^{\circ} 45'$	Secant, 0.057136	Cosine, 9.289600
P. D., $111^{\circ} 2'$	Co-Sec., 0.029945	— 584
		9.289016
2)157 33 50		
Half-sum, $78^{\circ} 46' 55''$	Co-Sine, 9.289016	Diff. 1061
Alt., — $17^{\circ} 46' 50''$		× 55
Rem. $61^{\circ} 00' 05''$	Sine, 9.941878,	5305
		5305
Hour Angle, $3^{\circ} 37' 3''$	= $9.31797,5$	583,55
	— 80	
	18 = 3s.	
9.941819	Diff. 117	
+ 59	5	
9.941878	58,5	

In this Example the Lat. and Decl. being of different names, and exceeding 90, the Secant of Decl. is taken instead.

True alt. $27^{\circ} 45' 20''$, Lat. $45^{\circ} 30' N.$, decl. $10^{\circ} 20' S.$
Required the Hour Angle, or App. time.

Decl. $10^{\circ} 20' S. \div 90 = 100^{\circ} 20' P. Dist.$

Alt., $27^{\circ} 45' 20''$			
Lat., $45^{\circ} 30'$	Secant, 0.154338		
P. D., $100^{\circ} 20'$	Co-Secant, 0.007102		
2)173 35 20	Co-Sine, 8.747553	8.749055	3756
		— 1502	× 40
Half-sum, $86^{\circ} 47' 40''$	Sine, 9.933242	8.747553	1502,40
27 45 20			
	8.842235	9.933217	126
Rem. $59^{\circ} 2' 20''$	— 175	+ 25	20
Hour Angle, 2h. 2m. 19s.			
	4s. = 59	9.933242	25,20

True alt., $40^{\circ} 37' 50''$, Lat. $36^{\circ} 40' S.$, decl. $12^{\circ} 25' 18'' S.$
 Required the App. time from noon, or Hour Angle.

$$\text{Decl. } 12^{\circ} 25' 18'' - 90 = 77^{\circ} 34' 42''$$

Alt. $40^{\circ} 37' 50''$			
Lat. $36^{\circ} 40'$	Secant, 0.095759		
P. D., $77^{\circ} 34' 42''$	Co-Secant, 0.010287	.010307	47
		— 20	42
<u>2)154 52 32</u>		<u>.010287</u>	<u>94</u>
Half-sum, $77^{\circ} 26' 16''$	Co-Sine, 9.337459		188
$40^{\circ} 37' 50''$	Sine, 9.777517		<u>19,74</u>
Rem. $36^{\circ} 48' 26''$	9.221022		
Hour Angle, 3h. 12m. 34s.	75	337610	945
		— 151	16
	27=4s.		
		337459	5670
			945
			<u>151,20</u>
		777444	
		+ 73	
		<u>77.7517</u>	281
			26
			<u>1686</u>
			562
			<u>73.06</u>

NOTE.—The Hour Angle can be found independent of Table XXXI, thus :—Divide the sum of the four logs by 2, take the result in Sine col., Table XXV, and the degrees at the top, and minutes in left col., which multiply by 2 and turned into time will give the Hour Angle.

Ex.—The sum of Logs in last question was $19.221012 \div 2$

Sine, 24 4 7	9.610511
× 2 next less,	477
<u>48 8 14</u>	
× 4	
<u>6.0)19,2 32 56</u>	Diff. 471)3400(07
	3297

Hour Angle, 3 12 33 nearly as above.

LONGITUDE BY CHRONOMETER.

In finding the Longitude by Chronometer, it is necessary to find the Mean Time at ship first, and the difference between that and the Mean Time shown by a Chronometer will be the Longitude in time; but both must agree in dates, that is,—it must not be one day at ship and another at Greenwich.

Suppose the Mean Time found at ship was 20h. 50m. 30s., Jan 20th, and Mean Time shown by Chronometer was 8h. 30m., on Jan. 21st. The diff. is 12h. 20m. 30s.; now, if this difference be multiplied by 60 and divided by 4, it will exceed any Longitude, that is,—it will exceed 180°.

$$\begin{array}{r} 12\ 20\ 30 \\ 60 \\ \hline 4)740\ 30 \end{array}$$

Long. in 185 7 30 E. — 360 00 = 174 52 30 W.

Therefore, 24 hours must be added to the date in advance, and put one day back to make both dates agree.

By adding 24 hours to the 21st day, shown by the Chronometer, it will reduce it to the 20th, then the difference is the Longitude.

Time by Chrono., 21st day,	^{h.} ^{m.} ^{s.}	8	30	00
		24		
M. T. Greenwich, 20th day,		32	30	00
M. T. at Ship, 20th day,		20	50	30
		11	39	30
		60		
		4)699	30	

Long. 174 52 30 W.

In the first case, the Longitude is East, as the ship's time is greatest, but of different dates; but in the latter it is W., as Greenwich is best, on same dates.

It has been explained already, that by adding 24 hours to the day in advance it will make it one day less, but it gains in the hours, as in the last example.

The Longitude may be found, in the first case, by leaving both times different dates and taking the result from 360° , and naming the Longitude opposite. It is more plain and simple to follow the last rule, which will not lead the learner into so many mistakes.

EXAMPLES.

1876, Jan. 31st.— At 3h. 50m., P. M., in Lat. $42^\circ 00' N.$, and Long. by acct. $50^\circ 50' W.$, the observed alt. $\odot$ was $14^\circ 15' 20''$ index cor. + 2m. 10s., height of eye 17 feet, when a Chrono. indicated 6h. 49m. 10s., which was slow 12m. 00s. 1t., on Greenwich Mean Time Jan. 2nd, and on Jan. 23rd slow 11m. 20s. 4t. Required the Long. in.

Inter., 21 days, from 2nd to 23rd Jan.		Long. 50 50
		4
Ship's time, ^{h m. s.} 3 50 00	Slow, 12 00 1	
Long. + 3 23 20	Slow, 11 20 4	6)20, 3 20
App. G. date, 7 13 20	Int. 21)39 7(1.9 gaining.	3 23 20
		21
Time by Chr., 6 49 10		
Orig. error, + 11 20 4	187	
		189
		d.
7 00 30 4	2nd Int. from 23rd to 31st.	8.3
Accl. rate, 15 0 gaining.		+ 1.9 d. r.
M. T. G., 31st, 7 00 14 4		747
		83
Obs. alt., ^{d. m. s.} 14 15 20	Decl., 31st, ^{d. m. s.} 17 28 42	15, 77
Cor., + 2 10	— 4 55	
14 17 30	Cor Decl., 17 23 47	31st, 41.72
Dip., — 3 57	+ 90 00 00	H. D. 32nd, 42.48
14 13 33	P. Dist., 107 23 47	2)84.20
Ref. par., — 3 33		
14 10 00		Mid. diff. 42.10
Semi-Di., + 16 16		7
		6)29, 4, 70
Cor. alt., 14 26 16		
		Cor., 4.55

Cor. alt.,	d	m.	s.				
	14	26	16				
Lat.,	42	00	00	Sec.	0.128927	0.020303	65
P. Dist.,	107	23	47	Co-Sec.	0.020272	31	47
				Co-Sine	9.148026		455
	2)163	50	3	Sine,	9.965550	0.020272	260
H. sum,	81	55	1		9.262775	965511	30, 55
Alt.,	14	26	16		65	+	39
							87
Rem.,	67	28	45		13 (2s.)	965550	45
H. angle,	h.	m.	s.				435
Equation, +	3	22	42				348
M. T. S.,	31st.,	3	56	25			39, 15
M. T. G.,	31st.,	7	00	15			
Long. in time,	3	23	50	Equation, 31st,	13 40	Diff.	378
	×	60			+	3	7
	÷ 4)203	50		Cor. Equation,	13.43		2, 646
Long. in,	50	57	30	W.			

In this example it was P. M. at ship and W. Longitude, and consequently of same date, so that the equation was added to H. A., without subtracting or adding 24 hours, and the difference between the Mean Time at ship and mean time at Greenwich gave the Longitude in time.

1876, Jan. 28th.—At 4h. 01m. P. M., in Lat. $28^{\circ} 45' N$. Long. by acct. $170^{\circ} 55' E$., alt. $\odot$ $17^{\circ} 46' 30''$, index cor. — 3m. 25s., height of eye 16 feet, time by Chrono. 4h. 31m. 30s., which was fast 1m. 16s. 2t. on Dec. 16th, 1875, and on Jan. 1st, 1876 slow 1m. 3s. for Mean Time at Greenwich. Required the Long. at ship at time of observation.

Ship's time, ^{h. m. s.} 4 01 00		Fast, 1 16 2	Long. 170°55
— 11 23 40		Slow, 1 3 0	4
App. G. date, 27th, 16 37 20		2 19 2	6,0)68,3 40
		6	
Chrono., ^{h. m. s.} 4 31 30			11 23 40
+ 1 3		Int. 16d.) 139·2 (8·7 losing.	
		128 26·7	Int. from Jan. 1st to Jan. 27th.
4 32 33			
+ 3 52		112 609	38·50
		112 522	39·33
4 36 25		174	
12 00 00			2)77·83
		6)23,2,29	
M.T.G. 27th, 16 36 25			38·91
		Acc. rate, + 3·52 losing.	G.D. 16·6
Alt., 17 46 30			
Cor. — 3 25		Decl. 18 32 53	23346
		10 47	23346
17 43 05			3891
Dip. — 3 50		Cor. Dec., 18 22 06	
			6,0)64,6906
17 39 15		Cor. Dec., 18 22 06	
Cor. ref. — 2 49		+ 90 00 00	10·47
17 36 26		P. D. 108 22 06	H. Diff. ·516
Semi-Di., + 16 17			16·6
		Equa., ^{m s.} 12·57	
T. Alt., 17 52 43		+ 9	3096
Lat., 28 45 00			3096
P. D., 108 22 06		Sec. 0·057136	
		Co. Sec. 0·022707	Cor. Eq. 13·06
		Co-sine, 9·335384	516
2)154 59 50		Sine, 9·935855	949
			55
H. sum, 77 29 55		9·351082	123
Alt., — 17 52 43		090	4745
			4745
59 37 12		18 (3)	14,76
			521,95

Hour Angle, 28th, 3 46 13

Eqn. + 13 7

3 59 20

24 00 00

M. T., Ship, 27th, 27 59 20

M. T., Greenwich, 27th, 16 36 25

11 22 55

60

4)682 55

Long. in, 170 43 45 E.

In the above example the Hour Angle was 28th day, P. M., but the ship being in a high E. Longitude, and that subtracted from time at ship brought the day back to the 27th, Greenwich date, and the H. A. was on the 28th, consequently they were of different dates, therefore 24 hours had to be added to ship's date, as it was in advance, to reduce it to the 27th day, and Greenwich date.

1876, Nov. 25th.—At 7h. 50m. A. M., Lat. $40^{\circ} 10' S.$, Long. $172^{\circ} 59' W.$, Alt. $\odot$ was $33^{\circ} 50' 50''$, index cor. + 1m. 15s., height of eye 18 feet, Time by Chron. 7h. 40m. 59s., which was fast 32m. 02s. Oct. 18th, and on Nov. 7th fast 29m. 50s. for Mean Time at Greenwich. Required the Longitude at time of observation.

	h. m.	Int. from Nov. 7th to 25th is	
Time at Ship,	7 5	18.3	fast 32 02 Oct. 18th
	12	$\times 6.6$	“ 29 50 Nov. 7th
	19 50	1098	2 12
Long. +	11 31 56	1098	60
	31 21 56	6)12.0.78	1st Inter. 20)132(6.6 losing.
	24		120
		2.1 acc. rate losing	
App. T. 25th,	7 21 56		120
			120

Time by Chr., 7 40 59	Long 172° 59'	
Org. error, — 29 50	4	
7 11 09	6,0)69.1 56	
Acc. rate, + 2 1	11 31 56	
M. T. G. 25th, 7 13 10	d. m. s.	
24 00 00	Decl. 25th, 20 53 35	2876
31 13 11	Incr., + 3 23	H. Dif. 2777
d. m. s.	Cor. Decl., = 20 56 58	2)5653
Obs. Alt., 33 50 50	90 00 00	2826
Cor. + 1 15	P. Dist. = 69 03 02	G. D. × 7.2
33 52 05	Equ. 12 40 14	5652
Dip. — 4 4	Dec., — 4 87	19782
33 48 01	Cor. Equ. = 12 45	60)20,3,472
Cor. 18, — 1 18	0.116809	3.23
33 46 43	0.029704	
Semi-Di., + 16 15	9.498444	H. D. .786
Cor. Alt. = 34 02 58	9.785274	G. D. × 6.2
Lat., 40 10 00	9.430231	1570
69 03 02		4716
Sum 2)143 16 00		4,87,30
Half-sum, 71 38 00	Hour Angle, 25th, 4 10 05	
Alt., — 34 02 58	24	
Rem'd, 37 35 02	App. T. G., 24th, 19 49 55	
	Equa., — 12 35	
	M. T. S., 24th, 19 37 20	
	M. T. G. 24th, 31 13 10	
	11 35 50	
	6	
	4)695 50	
	Long., = 173 57 30 W.	

In this example the Hour Angle had to be subtracted from

24 hours, it being A. M. when observation was taken, and changed the date to 24th, and the Greenwich date being the 25th, 24 hours had to be added to bring it to the 24th, same as ship's date, as it was the day in advance; the diff. then was the Long.

1876, Feb. 12th.—At 8h. 30m. A. M., Lat. $51^{\circ} 00' N.$, Long. by acct. $167^{\circ} 40' E.$, obs. Alt. $\odot 10^{\circ} 02' 50''$, index cor. — 2m. 50s., height of eye 19 feet, Time by Chron. 9h. 58m. 50s., which was fast 38m. 00s. 4t. Dec. 22nd, 1875, and on Jan. 12th, 1876, fast 35m. 02s. 4t. Required the Longitude at time of observation.

Ship's date, ^{h. m. s.} 8 30 00	Fast, 38 00 4	Long. 167.40
12	" 35 2 4	4
11th, 20 30 00	2 58 0	6, 0)67, 0.40
11 10 40	60	
		11 10 40
App. date, 11th, 9 19 20	1st Int. 21)178(8.5 losing.	
	168 × 30.4 2nd int. from	
Chrono. 9 58 50		12th Jan. to
Orig. rate, — 35 2 4	108 340	11th Feb.
	105 2550	
	9 2347 6	
Acc. rate, + 418 4	3 6)25, 8, 40	
G. M. T., = 9 28 06 0	4 18 acc. r. losing.	
Alt., 10 02 50	Decl. 11th, 14 07 52	4914
Cor., — 2 50	7 48	4972
10 00 00	Cor. Decl., 14 00 04	2)9886
Dip, — 4 11		4943
9 55 49	0.201128	G. D. × 9.47
Cor., — 5 9	0.013098	34601
9 50 40	9.112342	19772
Semi-Di., + 16 14	9.979283	44487
	9.305851	
Cor. Alt. = 10 06 54	68	6, 0)46, 8, 1021
Lat., 51 00 00		Cor. 7.48
P. D., 104 00 04	17 (3)	
Sum, 2)165 06 58		
Half sum, 82 33 29		
Alt., — 10 06 54		
72 26 35		

Equa. 14m. 30s. No. Cor.

Hour Angle 12th,		3 33 48
		24
	11th,	= 20 26 12
Equation,		+ 14 30
M. T. Ship 11th,	=	20 40 42
M. T. G. 11th,	=	9 28 6
		11 12 36
		60
		4)672 36
Long.	=	168 9 E.

TO FIND THE DEVIATION OF THE COMPASS BY AN AZIMUTH.

AZIMUTH is the angle at the Zenith between the meridian of the observer and the circle of altitude passing through the object.

The true Azimuth is found by adding together the Secant of the true Altitude, the Secant of the Latitude, the Co-Sine of the half-sum and the Co-Sine of the remainder. The remainder is found by subtracting the half-sum from the Polar distance, or if the half-sum is greater than the Polar distance, subtract the Polar distance from the half-sum. In either case it will be the remainder.

Half the sum of these four Logs., found in Table XXV., will give the Sine of half the true Azimuth, which, multiplied by 2, will be the true Azimuth.

TO NAME THE TRUE AZIMUTH.

If the Latitude is S., name the Azimuth N., and if the Latitude is N., name it S., (always opposite to the ship's Latitude) towards the E. in the morning, and towards the W. in the evening. That is, if the observation was taken in the morning, and

the Latitude of the ship S., the Azimuth would be N. and E., but in the evening it would be N. and W.

The difference between the True Azimuth and the Magnetic is the **Error**,—to be named E. if the True Azimuth is to the right of the Magnetic, but if to the left it is named W. Both Azimuths must be named from the same point; one cannot be N. and the other S.,—if so, subtract either one from 180° and it will change the name to the same as the other.

The Magnetic Azimuth is the bearing of the Sun from the ship by an Azimuth compass, fitted with sight vane and reflector, but as few of our merchant ships have them on board, a description of them here would be useless. A substitute may be simply found. Thus:—place a small piece of putty or dough on the centre of the ship's compass, stick into it any small rod, a piece of cane, or a straight stem from a broom, so as it will stand perpendicular, and the reflection on the compass will be the opposite bearings of the Sun, or Magnetic Azimuth, which will be accurate enough for any practical purpose. I have often practiced the latter method, and found the error, and had very little difficulty even when the motion of the ship was considerable. The Deviation is found the same as in an Amplitude, by placing under the Error the Variation (by changing the name), and if same name their sum will be the Deviation, but if of contrary names their difference will be the Deviation, named after the greater. The Polar Distance is found as given already,—that is, if Lat. and Decl. are same name take the Diff., but if contrary names, the sum. If the ship's latitude is 0, name the true Azimuth opposite to the declination.

If one Azimuth be named N. and E., and the other N. and W., their sum will be the error.

It must be remembered that the Deviation found is not the Deviation to be allowed on all courses steered,—it is only the Dev. for the point she is on at the time.

EXAMPLES.

Being P. M. at ship, the true Alt. was $50^\circ 20'$, Decl. $10^\circ 20'$ N., and Lat. $20^\circ 30'$ S. Required the true Azimuth.

P. Dist.,	d. m. 100 20			Decl.	d. m. 10 20 N.
Alt.,	50 20	Secant,	0.194961		90 00
Lat.,	20 30	Secant,	0.028412		— —
				P. Dist.,	100 20
	2)171 10				
Half Sum, —	85 35	Co-sine,	8.886542		
	100 20				
Rem.,	14 45	Co-sine,	9.985447		
			2)19.095362		
	20 40	Sine, =	9.547681		
	2				

T. Az. N., 41 20 W.

In this question it being P. M. at ship, and the Lat. S., the true Azimuth is named N. opposite to the Lat. and W. as it was P. M.

N. B.—There is no necessity to correct the Logs for (¹¹) seconds, as the nearest minute is sufficient. When the seconds are under 30 reject them, but 30 or over take one minute.

Being P. M. at ship, the true Alt. was $20^{\circ} 40'$, Decl. $23^{\circ} 10'$, S., Lat. was $50^{\circ} 50'$ S. Required the true Azimuth.

P. Dist.,	d. m. 66 50			Decl.	d. m. 23 10 S.
Alt.,	20 40	Secant,	0.028887		90 00
Lat.,	50 50	Secant,	0.199573		— —
				P. Dis.	66 50
	2)138 20				
Half sum,	69 10	Co-sine,	9.551024		
	66 50				
Rem.,	2 20	Co-sine,	9.999640		
			2)19.777124		
	77 5	Sine, =	9.888562		
	2				

T. Az. N. 154 10 E.

In this Example the Lat. and Decl. are same name, the Diff. is Polar Dist., and the Half Sum exceeds it, so the Polar Dist. had to be subtracted from the Half Sum to get a remainder.

THE TRUE AND MAGNETIC AZIMUTH GIVEN TO FIND THE ERROR.

Suppose True Azimuth was N. $41^{\circ} 20'$ W., and the Magnetic Azim N. $30^{\circ} 20'$ W. Required the Error.

		d.	m.
True Azimuth	N.,	41	20 W.
Mag.	“ N.,	30	20 W.
Error,		= 11 00	

In the above example the True and Mag. Azimuths are both reckoned from the same point, N., and their Diff. is the Error, and is named W., because, by looking from the centre of the compass in the direction of both Azimuths, it will be seen that the True Azimuth is more to the W. than the Magnetic Azimuth, and also to the left of it, and is named W.

Suppose the True Azimuth was N. $154^{\circ} 10'$ E., and the Magnetic S. $40^{\circ} 30'$ E. Required the Error.

		d.	m.
True, N.,		154	10 E.
		180 00	
	S.,	24	50 E.
Mag. Az. S.,		40	30 E.
Error,		15 40 E.	

In this case the True and Magnetic Azimuths are of contrary names; the True had to be subtracted from 180° , which changed its name from N. to S., the same as Magnetic, and the difference is the error.

Suppose the true Azimuth was S. $5^{\circ} 40'$ W., and Magnetic was S. $10^{\circ} 50'$ E. Required the Error.

		d.	m.
True Azimuth, S.,		5	40 W.
Mag.	“ S.,	10	50 E.
Error,		16 30 E.	

In this case one Azimuth was S. and W., and the other S. and E. Both added gives the Error.

TO FIND THE DEVIATION BY AN AZIMUTH.

1876, May 30th, at $3^{\circ} 30' 40''$, P. M., in Lat. $41^{\circ} 58'$ N.,

Long. $95^{\circ} 40'$ W., Sun's Mag. Azimuth N., $120^{\circ} 30'$ W., Alt. $\odot$ $45^{\circ} 40' 50''$, Index Cor. $+ 2' 15''$, height of eye 12 feet, and the variation by Chart was $12^{\circ} 20'$ E. Required the Deviation.

Ship's Time,	^{h.} ^{m.} ^{s.} 3 30 40	Decl. 20th, =	^{d.} ^{m.} ^{s.} 20 06 53
Long. +	6 22 40		+ 5 5
App. G. Date 20th, =	9 53 20	Cor. Decl., =	20 11 57
			90 00 00
Obs'd Alt.,	^{d.} ^{m.} ^{s.} 45 40 50	P. Dist.,	69 48 03
Ind. Cor.,	+ 2 15	Alt.,	45 54 48
	45 43 05	Lat.	41 58
Dip., —	3 19		
	45 39 46		2)157 40 51
Cor. table 18, —	48	H. Sum,	78 50 25
	45 38 58		— 69 48 3
Semi-Dia. +	15 50	Rem'r,	9 2 22
True Alt.,	45 54 48		
	37 27	H. Diff.	3080
	2	G. Date, ×	99
True Az. S.,	74 54 W.		27720
	180 00		27720
" " N.,	105 6 W.		60)3049 20
Mag. " N.,	120 30 W.		55
Error,	15 24 E.		
Variation,	12 20 W. c. name.	co-secant,	0.157706
		co-secant,	0.128699
Deviation,	3 4 E. after greatest.	co-sine,	9.287048
		co-sine,	9.994580
		sum, 2)	19.568033
		sine, =	9.784016

The Declination and Lat. being of same name, their Diff. is the polar dist. The True Azimuth is named S. and W., and

Magnetic N. and W. The True is taken from $180'$, which changes the name N., and same as Magnetic, their Diff. is then the Error, named E. As True is to the right of Magnetic, then change name of Variation from E. to W., and as the Error and Variation are of contrary names, their Diff. is the Deviation named after the greatest.

AZIMUTH.

1876, Dec. 26th, at 8h. 10m. 20s. A. M., Lat. $16^{\circ} 02' N.$, Long. $129^{\circ} 30' W.$, Mag. Azimuth S. $70^{\circ} 19' E.$, Obs'd Alt. $\odot 20^{\circ} 15'$, Index cor. $+ 2' 5''$, height of eye 16 feet, and Variation by Chart was $6^{\circ} 59' E.$ Required the Deviation.

	h.	m.	s.		d.	m.	s.
Ship's Time,	12	00	00	Obs'd Alt.,	20	15	00
	8	10	20	Index Cor.	+	2	05
	20	10	20			20	17 05
Long.	8	38		Dip.	—	3	50
	28	48	20			20	13 15
	24			Cor. Alt. 18,	—	2	26
Ap. G. Date 26th, =	4	48	20			20	10 49
P. Dist.,	113	20	58	Semi Dia.	+	16	18
Alt.	20	27	7	T. Alt.		20	27 07
Lat.	16	2					
Sum,	2)149	50	05	Secant,		0.028271	
				Secant,		0.017231	
H. Sum, —	74	55	02	Co-sine,		9.415347	
P. Dist.,	113	20	58	Co-sine,		9.893946	
				Sum,	2)9.354795		
Rem., =	38	25	56	Sine, =	9.677397		
Half Az.,	28	24					
	2			Long.	129	36	4
True Az. S.,	56	48	E.				
Mag. Az. S.,	70	19	E.		6, 0)51, 8	00	
Error,	13	31	E.			8	38 00
Var.,	6	59	W. change name.				
Devi.,	6	32	E. after the greatest.				

Decl. 26th,	23 21 27	H. Diff.,	395
	— 29	G. D.,	× 4·8
Cor. Dec.,	23 20 58		4760
	90 00 00		2380
P. Dist.,	113 20 58		28,560

In this question the declination being S., and Lat. N., their Sum is the P. Dist. The Sum of Logs gave the Sine of half the True Azimuth, which, multiplied by 2, gives True Azimuth reckoned from opposite Lat. S. towards the E., it being A. M. Now, as the Magnetic Azimuth is reckoned from S., they are of the same name, and the Diff. is the Error, named E., as the True Azimuth is to the right of the Magnetic, then the Variation given on the Chart is $6^{\circ} 59'$ E.—is changed to W., and as they are of contrary names their Difference is the Deviation named after the greatest.

AZIMUTH.

1876. March 19th, at 9h. 3m. A. M., in Lat. $42^{\circ} 59'$ N., Long. 91° W., Sun's Magnetic Azimuth S. $45^{\circ} 01'$ E., Alt. $\odot$ $32^{\circ} 40'$, height of eye 18, and Var. by Chart $25^{\circ} 29'$ W. Required Deviation.

Time at Ship,	h. m.	Decl. 19th,	d. m. s.	Long. 91
	9 5		0 17 57	4
	12		— 3 8	
18th,	21 5	Cor. Decl.	= 0 14 49	6)36,4
Long. +	6 4		+ 90 00 00	—
	27 9	P. Dist.	90 14 49	6·4
	24			

Ap. G. Date 19th, = 3 9

H. Diff. 59 27

3

Obs. Alt. 32 40 00

Dip., — 4 4

9' = 6, 177 81

9 88

32 35 56

Cor. Alt. 18th, — 1 21

6,0)18,7,69

32 34 35

3.8

Semi-Diam., + 16 5

True Alt., 32 50 40

= 0.075672

Lat., 42 49

= 0.135755

P. Dist. 90 14 49

= 9.083332

9.996546

2)165 54 29

2)19.291305

H. Sum, 82 57 14

9.645652

Rem., 7 17 35

Sine, S., 26 16 E.

2

True Az. S., 52 32 E.

Mag. Az. S., 45 1 E.

Error, 7 31 W.

Var., 25 59 E. change name.

Deviation, 18 28 E.

1876. Feb. 26th, at 2h. 30m. P. M., in Lat. $4^{\circ} 50' N.$, Long. $166^{\circ} 50' E.$, Magnetic Azimuth N. $116^{\circ} 34' W.$, Obs. Alt. $\odot$ $60^{\circ} 36' 50''$, height of eye 19 feet. Required the Deviation, Variation to be $7^{\circ} 15' E.$

 Ship's Time, ^{h. m.} 2 50

24

Obs. Alt.,

^{d. m. s.} 60 36 50

Dip.,

4 11

25th, 26 50

60 32 39

11 7 20

Cor. 18,

28

App. G. Date 25th, 15 42 40

60 32 11

Semi-Dia., + 16 11

True Alt., = 60 48 22

P. Dist.,	98 58 26		
Alt.,	60 48 22		
Lat.,	4 50	= 0.311705	Long., 166 50
		= 0.001547	4
Sum,	2)164 36 48	= 9.127060	
		= 9.981361	6,0)667 20
H. Sum, —	82 18 24		
P. Dist.,	98 58 26	= 2)19.421673	11 7 20
Rem.,	16 40 2	Sine, = 9.710836	
Half Az.,	^{d. s.} 30 55	Decl. 25th, ^{d. s. m.} 9 13 00	
	2	— 14 34	
True Az. S.,	61 50 W.	Cor. Decl., 8 58 26	
	180	90 00 00	
N.,	118 10 W.	P. Dist., 98 58 26	
Mag. Az. N.,	116 34 W.	H. Diff., 55 67	
		G. Date, × 15 7	
Error,	1 36 W.		
Var.,	7 15 W. change name.	38969	
		27835	
Dev.,	8 51 W.	5567	
		6,0)8,7,4,019	
		14 34	

FINDING THE LATITUDE BY REDUCTION TO THE MERIDIAN.

When the Sun's Altitude cannot be obtained at noon to get the Latitude, an Altitude may be taken about 30 minutes either before or after noon, (and by two corrections, one for the corrected declination, and another for the corrected altitude, found in Towson's Tables,) the Latitude thus found will not differ materially from that at noon, and will answer for all practical purposes.

RULE.—The first thing to be done is, find the time from noon or (hour angle,) put down the time shown by watch (if a. m.,) add 12 hours, add or subtract what she is fast or slow, as the case may be. Then if the ship changed her longitude since the watch was regulated, (which is generally done about

8h. A. M.,) turn the longitude into time, and if it is E. add, but W. subtract, and the result is the hour angle. But if it is A. M. it must be subtracted from 24 hours, for the hour angle found will be from the preceding noon, and the hour angle required must be from the nearest noon. If P. M. when the observation was taken, the time past noon will be the hour angle.

The next thing is, the Greenwich date has to be found. To correct the declination to the apparent time shown by watch, add W. longitude, and subtract E.; if A. M., subtract from the hours, minutes and seconds that are taken from 24 to find the hour angle, but if P. M., to the hour angle itself; and it will give the Greenwich date.

NOTE.—The difference of long. that the ship makes is to be applied the opposite to find the hour angle to the Longitude of the ship to find a Greenwich date.

TO FIND THE HOUR ANGLE.

EXAMPLES.

Jan. 26, P. M., at 0h. 30m. 40s. by watch, which was found to be fast 10m. 22s. on app. time, the diff. of Long. made to the E. $31\frac{1}{4}$. Required the Hour Angle at the time of observation.

	h.	m.	s.		
Time by watch,	0	30	40	Diff. Long.	31.4
Fast,	—	10	22		4
		20	18		<u>6</u> 12, 5, 6
Diff. Long. E.,	+	2	6		<u>2.6</u> nearly.
Hour Angle, =		22	24		

In this Example the watch showed 0h. 30m. 40s., and was fast 10m. 22s., which had to be subtracted, and since the watch was regulated she changed her time 2m. 6s., which had to be added also, as the watch was losing on time going to the E., and the result was the Hour Angle.

Feb. 27th, P. M., at 2h. 20m. 30s. by watch, which was found to be fast 2h. 21m. 10s. on app. time, the diff. of Long. made to the E. since the watch was regulated was $38\frac{1}{6}$.

	h.	m.	s.		
Time by watch,	2	20	30	Diff. Long.,	38.6
Fast,	—	2	21		4
		23	59		<u>6</u> 15, 4.4
Feb. 26th,		23	59		
+		2	34		<u>2,34.4</u>
Hour Angle,	00	1	54		

In this case the watch was faster than the time shown by her past noon; then a subtraction could not be made without borrowing 24 hours, and that put the time back to the 26th, but as the ship was making Easting, that time had to be added, and exceeded 24 hours by 1m. 54s., which was the Hour Angle past noon.

March 30th, P. M., at 0h. 20m. 40s. by watch, which was slow 10m. 20s., and diff. Long. made to the W. $15^{\circ}4'$. Required Hour Angle.

	h. m. s.	
Time by watch, 0	20 40	Diff. Long. $15^{\circ}4'$
+	10 20	4
	31 00	$6)6,1,6$
—	1 2	1·2 nearly.
Hour Angle,	29 58	

April 10th, A. M., at 11h. 20m. 40s. by watch, which was found to be slow 10m. 20s. on app. time, the diff. Long. made to the W. since the watch was regulated was 14m. 8s. Required the Hour Angle.

	h. m. s.	
Time by watch, 11	20 40	Diff. Long., 14 8
+	12	4
	23 20 40	$59, 2$
April 9th, 23	20 40	
Slow, +	10 20	
	23 31 00	
—	59	
	23 30 01	
9th,	24	
Hour Angle,	29 59	

It was A. M. when the observation was taken, and when all the corrections were applied it was 23h. 30m. 1s. from apparent noon on the 9th, but as the Hour Angle is required for the nearest noon, that time had to be taken from 24 hours, and the result, 29m. 59s., was the Hour Angle.

May 20th, A. M., watch showed 4h. 50m. 20s., which was found to be 5h. 10m. 10s. fast on app. time, and diff. Long. made to the W. since the watch was regulated was $19^{\circ}8'$. Required the Hour Angle from nearest noon.

Time by watch,	^{h.} ^{m.} ^{s.} 4 50 20	Diff. Long.,	19 1/8
Fast,	— 5 10 10		4
	<u>23 40 10</u>		<u>6, 0) 7, 9 2</u>
	— 1 19		<u>1 19</u>
	<u>33 38 51</u>		
	24		
Hour Angle,	= 21 09		

In this example it was A. M. at ship, and the watch showed 4h. 50m. 20s., which could not be in the forenoon, and if 12 hours were added would be = 16h. 50m. 20s., and the 5h. 10m. 10s. she was fast subtracted, would give 11h. 40m. 10s. the previous day, when no observation could be taken. To find the correct Hour Angle 24 hours had to be added to what the watch showed, and what she was fast subtracted, and diff. of Long. also, and the result subtracted from 24 hours gave Hour Angle.

1876. May 20th, A. M., Long. $106^{\circ} 40'$ W., Obs. Alt. $\odot$ N. was $31^{\circ} 50' 40''$, Index Cor. + $52''$, height of eye 20 feet, time by watch 4h. 50m. 20s., which was found to be fast 5h. 10m. 10s. on app. time at ship, diff. Long. made W. since the watch was regulated was $19 1/8$. Required the Lat.

Time by watch,	^{h.} ^{m.} ^{s.} 4 50 20	Diff. Long. $19 1/8$	Long. $106 40$
Fast,	— 5 10 10	4	4
	<u>23 40 10</u>	<u>6) 7, 9, 2</u>	<u>6, 0) 42, 6 40</u>
Change of time,	— 1 19	<u>1 19</u>	<u>7 6 40</u>
App. T. Ship 19, =	<u>23 38 51</u>		
	24 00 00	Sun's Decl. 20th, ^{d.} ^{m.} ^{s.} 20 06 50	
	<u>21 09</u>	Cor. +	<u>3 25</u>
H. Angle,	21 09		
	<u>23 38 51</u>	Cor. Decl. =	<u>20 10 15</u>
App. T. Ship,	23 38 51	1st August, +	<u>4 42</u>
Long. +	7 6 40		
	<u>30 45 31</u>	Aug. Decl.,	<u>20 14 57</u>
	— 24		
	<u>6 45 31</u>		
G. Date 20th,	6 45 31		

Obs. Alt.,	31 50 40 N.		3080
Cor.,	+ 52	H. Diff.,	2994
	31 51 32		2)6074
Dip.,	- 4 17		
		Mid. Time, =	3037
	31 47 15	G. Date, +	676
Ref. 18th,	- 1 25		
			18222
	31 45 50		21259
Semi-Dia.,	+ 15 50		18222
True Alt.,	32 01 40		6,0)20,5,2992
Aug. 2nd,	+ 8 9		
			3 25
Aug. Alt.,	32 09 49		
	90 00 00	Hour Angle and Decl. gave In-	
		dex (49).	
Zen. Dist.,	57 50 11 S.		
Decl.,	20 14 57 N.	Index for 48, =	^{m. s.} 7 56
		" " 52, =	8 36
Lat.,	= 37 35 14 S.		
			3)40
			+ 13
			7 56
		Cor. Aug.,	8 9

This is the same example as the last, and gives same Hour Angle. But all the corrections are employed here and the Lat. found. It was A. M. at ship, and the app. time found was from noon of the previous day, which had to be subtracted from 24h., and gave the Hour Angle from nearest noon. In taking H. Angle, 21h. 09m., (from Towson's Tables,) agreeing with Decl., gives Index No. (49), which could not be found under the Alt., the nearest two, 48 and 52 had to be used, their difference taken, and, divided by 3, gave a correction to be added to the next less augmentation, 7.56, and gave 8' 9'', correct augmentation for Alt.

NOTE.—Even by taking the nearest Index to (49) = 48, and taking the direct cor., 7' 56'', it would make only a difference of 13'', which would make no material error in the Lat. It should be remembered that in an A. M. observation it must be 23 hours app. time, and p. m. no hours.

EXAMPLES.

1876. Jan. 26th, P. M., Long. $52^{\circ} 20'$ E., obs. Alt. $\odot$ N., was $55^{\circ} 50' 40''$, Index cor. — $2' 9''$, height of Eye 19 feet, time of watch 30m. 40s., which was found to be fast $10' 22''$ on app. time at ship, diff. Long. made to the E. since the watch was regulated was $31' 4$. Required the Lat.

Time by watch,	^{h.} 00 ^{m.} 30 ^{s.} 40	Diff. Long. $31' 4$	Long. ^{d.} 52 ^{m.} 20
Fast,	10 22	4	4
	00 20 18	6.0)12.5.6	6.0)20.9 20
Change of time,	+ 2 6		
		2 6 nearly.	3 29 20
Hour Angle,	00 22 24		
		Decl. 25th,	19 2 52
Long.,	— 3 29 20	Cor.	— 12 58
G. Date 23rd, =	20 53 04	Cor. Decl., =	18 49 54
	^{d.} 55 ^{m.} 50 ^{s.} 40	Aug. 1st, +	5 6
Obs. Alt.,	55 50 40		
Index Cor.,	— 2 9	Aug. Decl.,	18 55 00
	55 48 31		
Dip.,	— 4 11	H. Diff.,	3679
			3765
	55 44 20		
Ref. 18,	— 49		2)7444
	55 43 32	Mid. Time,	3722
Semi-Dia., +	15 49	G. Date,	20.9
	55 59 20		33498
True Alt.,	55 59 20		74440
Aug. 2nd, +	10 46		
			6.0)77.7.890
Aug. Alt.,	56 10 06		
	90 00 00		1258 nearly.
Zen. Dist.,	33 49 54 S.	Hour Angle and Decl. gave	
Decl.,	+ 18 55 S.	Index (55).	
		Corresponding Cor. for Alt.	
Lat.,	52 44 54 S.	= $10' 46'$	

In this example, after the correction being applied to the watch, and the change of time made E., it gave the Hour Angle; it being P. M. at ship, and the diff. of ship's Long. subtracted because E., gave Greenwich date. With the Hour

Angle $22' 24''$, and the cor. decl. gave first Augmentation for decl. $5' 6''$ and corresponding No. (55) under the True Alt. gave second Augmentation for Alt. $10' 46''$.

1876. April 9th, A. M., in Long. $30^{\circ} 10'$ W., obs. Alt. $\odot$ S., was $36^{\circ} 59' 50''$, Index cor. — $1' 4''$, height of eye 12 feet, time of watch 1h. 02m., which was found to be fast 1h. 21m. 20s. on app. time, and diff. Long. made to the E. was $21' 2''$. Required the Lat. by reduction to the Meridian.

Time by watch,	^{h.} 1 ^{m.} 2 ^{s.} 00	Diff. Lon. E., $21' 2''$	S. Lon. ^{d.} 53 ^{m.} 10 W.
Fast,	1 21 10	4	4
	33 40 50	8 4 8	6)21 230
Chg. of time, +	1 25	1 25 nearly.	3 32 40
Ap. time 8th,	23 42 15	Decl. 9th,	7 48 54
	24	Cor., +	3
Hour Angle,	17 45	Cor. Decl.,	7 51 54
		Aug., +	1 24
App. time,	23 42 15	Aug. Decl.,	7 53 78
+	3 32 40	H. Diff.,	55 52
G. Date 9th,	3 14 55		55 19
Obs. Alt.,	36 59 50		
Cor., —	1 4		2)110 71
	36 58 46	Mid. Diff.,	55 35
Dip., —	3 19	G. Date,	3 23
	36 55 27		27 675
Ref. 18, —	1 9		11070
	36 54 18		16605
Semi-Dia., +	16		6,0)179,8875
True Alt.,	37 10 18		
Aug., +	7 35		2,59 = 3' nearl.y
Aug. Alt., =	37 17 53	Decl. and Hour Angle gives	
	90 00 00	Aug. 1st $1' 24''$ and Index	
Zen. Dist.,	52 42 07 N.	(38). Index and T. Alt.	
	7 53 18 N.	gives Aug. 2nd $7' 35''$.	
Lat., =	60 35 25 N.		

The Index 38 could not be had under the Alt., but 36 and 40, so both were added and divided by us and given Aug. 2nd, 7' 35''.

1876. June 16th, A. M., Long. $24^{\circ} 50'$ E., obs. Alt. $\odot$ N. was $33^{\circ} 10' 15''$, Index Cor. $-2' 10''$, height of eye 17 feet, time by watch 0h. 59m. 58s., which was found to be fast 1h. 18m. 20s. on app. time, diff. Long. made to the E. since the watch was regulated was $13^{\circ} 7'$ Required the Latitude.

Time by watch,	^{h.} 0 ^{m.} 59 ^{s.} 58	Obs. Alt.,	^{d.} 33 ^{m.} 10 ^{s.} 15
Fast,	— 1 18 20	Cor.	— 2 10
	<u>23 41 38</u>		<u>33 08 05</u>
Diff. Long. +	55	Dip., —	3 57
App. T. ship,	<u>23 42 33</u>		<u>33 04 68</u>
	24	Ref. 1th, —	1 20
Hour Angle, =	<u>17 27</u>		<u>33 02 48</u>
App. T. ship,	23 42 23	Semi-Dia., +	15 47
Long. of ship, —	<u>1 39 20</u>	Trxe Alt.,	33 18 35
G. Date 15th,	22 03 13	Aug., +	5 33
			<u>33 24 08</u>
Cor. Dec.,	23 32 57	Aug. Alt.,	90 00 00
Aug., +	<u>3 33</u>		
Aug. Decl.,	23 26 30	Zen. Dist.,	55 35 52 S.
		Aug. Decl.,	23 26 30 N.
	5 79		
Half Diff.,	<u>4 76</u>	Lat.,	33 09 22 S.
	Decl. 15th, 23 20 58.	Diff. Long. 13 ⁷ / ₈	
	2)105 5	1 59	4
	<u>5 27</u>		
Mid Time,	5 27	Cor. Decl., 23 22 57	54, 8
G. Date, +	<u>22 5</u>		
	2635	Decl. and H. A. = Aug. 1st, 3' 33''	
	1054	Index (32) & Alt. = Aug. 2nd, 5 48	
	<u>1054</u>		
	[6,0)11.8,585		
Cor. +	<u>1.59</u>		

TO FIND THE LATITUDE BY A FIXED STAR.

There is very little difference between finding the Lat. by a Meridian Alt. of the Sun and finding it by a fixed Star. In fact it is more easily found by the stars; the dip and refraction is found the same as for the sun (semi-diameter and parallax rejected) and the declination requires no correction.

RULE.—Correct the Alt. for dip and refraction, then find the star in the Nautical Almanac, page 297 @ 299, and note the right ascension (this is an index), then find that right ascension from page 236 @ 237, and in the next column to the right will be found the declination with the hours and minutes at the top and seconds down the col. There cannot be a mistake made as no other star will have the same right ascension.

EXAMPLES.

1876. Jan. 11th. The obs. Alt. of the Star α Leonis (Regulus) was $50^{\circ} 40' 30''$ N., Index cor. — $1' 30''$, height of eye 22 feet. Required the Latitude.

Obs. Alt.	d. m. s.
	50 40 30 N.
Index Cor.	— 1 30
	50 39 00
Dip, —	4 30
	50 34 30
Ref., —	47
	50 33 43
True Alt.,	90 00 00
	39 26 17 S.
Decl.,	12 34 19 N.
	16 51 58 S.

(Regulus) was found in page 298, N. A., and abreast stood right ascension, 10h. 1m., which was taken for an Index, and found at page 345 (Fixed Stars), marked R. A., and over it (Regulus), the Star required, then, by looking down the extreme left hand col., marked at top (month and day), and abreast of 11th day, and under col. Decl. will be the Decl. to be added, or subtracted, according to the name of the Zenith dist.

1876. Feb. 20th. Obs. Alt. of the Star α Argus (Canopus) S. was $59^{\circ} 20' 30''$, height of eye 14 feet. Required the Lat.

Obs. Alt.	d.	m.	s.	
	59	20	30	S.
Dip., —		3	36	
	59	16	54	
Ref., —			30	
	59	16	24	
	90	00	00	
Z. Dist.,	30	43	36	N.
Dec.,	52	37	51	S.
Lat.,	21	54	15	S.

TO FIND THE DEVIATION OR LOCAL ATTRACTION OF THE COMPASS.

Deviation or local attraction, so caused by the iron used in the construction of the ship, also the cargo she takes on board, particularly iron. The Deviation so caused can be found by swinging the vessel to at least eight points of the compass, and taking the bearing of any conspicuous distant object, and note each bearing when the ship's head is at each point, and if they are all from the same point of the compass, or have like names, add all together and divide by 8 and the result will be the correct magnetic bearing.

But if some of the bearings are from the N. and others from the S., subtract the less from 180 and they will have like names. But if some are named N. and E. and others N. and W. subtract the least from the greater, and divide by 8.

TO NAME THE DEVIATION.

If the correct magnetic bearings thus found falls to the right of compass bearings, it will be E., but if to the left, W. For instance,—if correct bearing of distant object was N. $32^{\circ}30'$ W., and compass bearing N. $42^{\circ}30'$ W. — $42^{\circ}30' = 10^{\circ}$ the Deviation is E., this time falling to the right.

The following form is given at the Examination Board, and the Candidate has to fill the Deviation column :—

Ship's Head.	Bearing of Dist. Object.	Deviation Required.	The Deviation is found as follows :
N.,	N. 41 20 W.		Ship's head at N.
N. E.,	N. 57 30 W.		Cor. Mag. bear'g N. 41 19 W
E.,	N. 63 10 W.		Compass bear'g N. 41 20 W
S. E.,	N. 59 40 W.		Deviation, 0 1 E
S.,	N. 44 30 W.		Ship's head at N. E.
S. W.,	N. 23 20 W.		Cor. Mag. bear'g N. 41 19 W
W.,	N. 18 00 W.		Compass bear'g N. 57 30 W
N. W.,	N. 23 00 W.		Deviation, 16 11 E
Ship's Head.	Bearing of Dist. Object.	Deviation Required.	
N.,	N. 41 20 W.	0 01 E.	Ship's head at E.
N. E.,	N. 57 30 W.	16 11 E.	Cor. Mag. bear'g N. 41 19 W
E.,	N. 63 10 W.	21 51 E.	Compass bear'g N. 63 10 W
S. E.,	N. 59 40 W.	18 21 E.	Deviation, 21 51 E
S.,	N. 44 30 W.	3 11 E.	Ship's head at S. E.
S. W.,	N. 23 20 W.	17 59 W.	Cor. Mag. bear'g N. 41 19 W
W.,	N. 18 00 W.	23 19 W.	Compass bear'g N. 59 40 W
N. W.,	N. 23 00 W.	17 19 W.	Deviation, 18 21 E

8)330 30

Cor.M. bgs. 41 19

Ship's head at S.
Cor. Mag bear'g N. 41 19 W
Compass bear'g N. 44 30 W

Deviation, 3 11 E

Ship's head at S. W.
Cor. Mag. bear'g N. 41 19 W
Compass bear'g N. 23 20 W

Deviation, 17 59 W

Ship's head at W.
Cor. Mag. bear'g N. 41 19 W
Compass bear'g N. 18 00 W

Deviation, 23 19 W

Ship's head at N. W.
Cor. Mag. bearing N. 41 19 W
Compass bearing N. 23 00 W

Deviation, 38 19 W

The compass bearings are all added together, and the sun divided by 8, the result is correct magnetic bearing, and placed in the Deviation column, and if correct magnetic bearings is to the right it is to be named E., but if to the left, W.

The candidate also is given two correct magnetic courses to find the compass course, and two compass courses to find true. From Napier's Curve, also, he has to take the bearings of two light-houses or two beacons, whose geographical position is known, and find the Deviation for the ship's head.

Napier's Curve has a vertical line divided into 360 equal parts, also the points of the compass. The vertical line is crossed at an angle of 60 by two lines,—one a plain and the other a dotted,—the plain line represents the true course, and the dotted the compass course. When the ship is swung to the eight points a course is made, showing the deviation whether E. or W., the Easterly deviation is to the right of the vertical line, and Westerly to the left. If the true course be given to find a compass, take a pair of dividers, and rest one leg on the vertical line, extend until the other leg touches the curve (parallel with the plain line) then return parallel with the dotted, and where it touches on the vertical line will be the compass course. If compass be given to find the true course go off on the dotted line and return by the plain, and the course indicated on the vertical will be the true course required. The following lines ought to be committed to memory, and the learner would seldom mistake the course:—

“If compass be given magnetic to gain,
Depart by the dotted return by the plain.”

“But if true course be given to find an allotted,
Depart by the plain and return by the dotted.”

From the following table find correct magnetic bearing of distant object, and Deviation for each point swung to:—

Ship's Head.	Bearing of Dist. Object.	Deviation Required.	Devi. for each Bearing is found as in the following form.
N.,	N. 10 10 W.	4 33 W.	Head at N. Cor. Mag. bearing N. 14 43 W Compass bearing N. 10 10 W Deviation, 4 33 W
N. E.,	N. 30 20 W.	15 37 E.	
E.,	N. 35 10 W.	20 27 E.	
S. E.,	N. 30 00 W.	15 17 E.	
S.,	N. 20 00 W.	5 17 E.	
S. W.,	N. 2 20 E.	17 3 W.	
W.,	N. 5 00 E.	19 43 W.	
N. W.,	N. 0 40 E.	15 23 W.	

N. and W., 125 40

N. and E., — 8 00

 8)117 49

Cor. Mag. Bng. 14 43 nearly.

Head at E.

Cor. Mag. bearing N. 14 43 W

Compass bearing N. 35 10 W

 Deviation, 20 27 E

Head at S.

Cor. Mag. bearing N. 14 43 W

Compass bearing N. 20 00 W

 Deviation, 5 17 E

Head at W.

Cor. Mag. bearing N. 14 43 W

Compass bear'g + N. 5 00 E

 Deviation, 19 43 W

Head at N. E.,

Cor. Mag. bearing N. 14 43 W

Compass bearing N. 30 20 W

 Deviation, 20 27 E

Head at S. E.

Cor. Mag. bearing N. 14 43 W

Compass bearing N. 30 00 W

 Deviation, 15 17 E

Head at S. W.

Cor. Mag. bearing N. 14 43 W

Compass bear'g + N. 2 20 E

 Deviation, 17 03 W

Head at N. W.

Cor. Mag. bearing N. 14 43 W

Compass bear'g + N. 0 40 E

 Deviation, 15 23 W

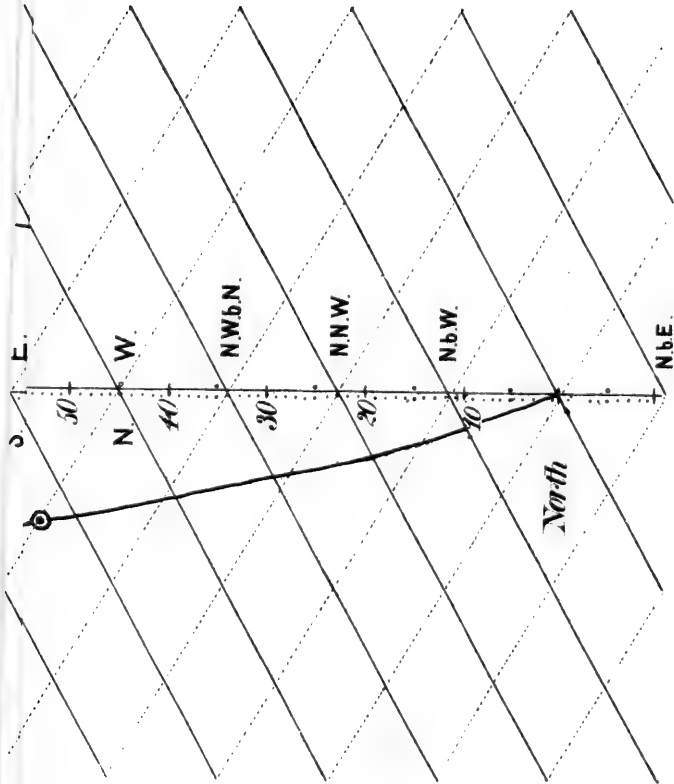
In this example while swinging the dist object bore N. and W. at 5 bearings, and N. and E. at 3 bearings. Then the 5 N. and W. bearings had to be added separately, also the 3 N. and E. bearings, and the less subtracted from greater, the result divided by 8 gave N. $4^{\circ} 43'$ W. the correct magnetic bearing.

In finding the Deviation for each bearing, when correct magnetic bearing and compass bearing had same name their difference was the Deviation; but when different names, their sum, that is, one was N. and W. and the other N. and E.—[See the work above.

PAPER FIRST.

Multiply 234

Divide 4567



Capt. R. Connolly.

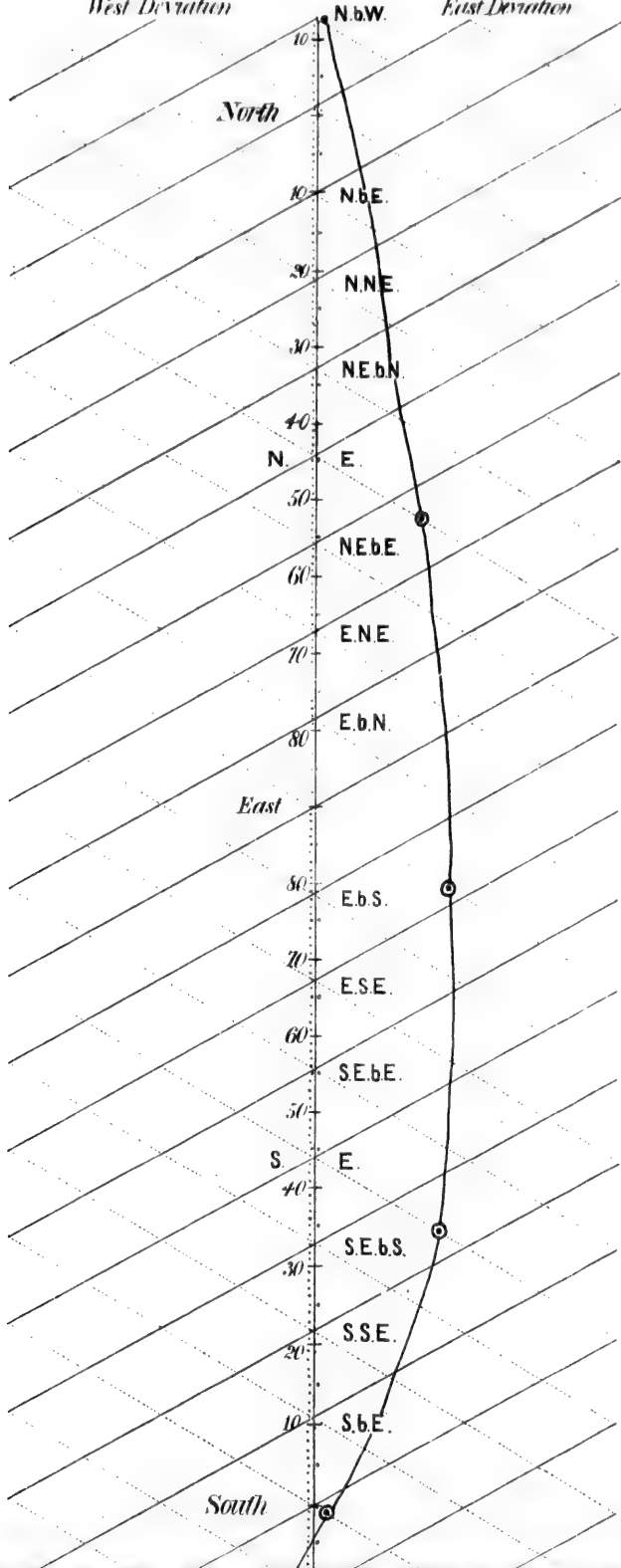
NAPIER'S DIAGRAM

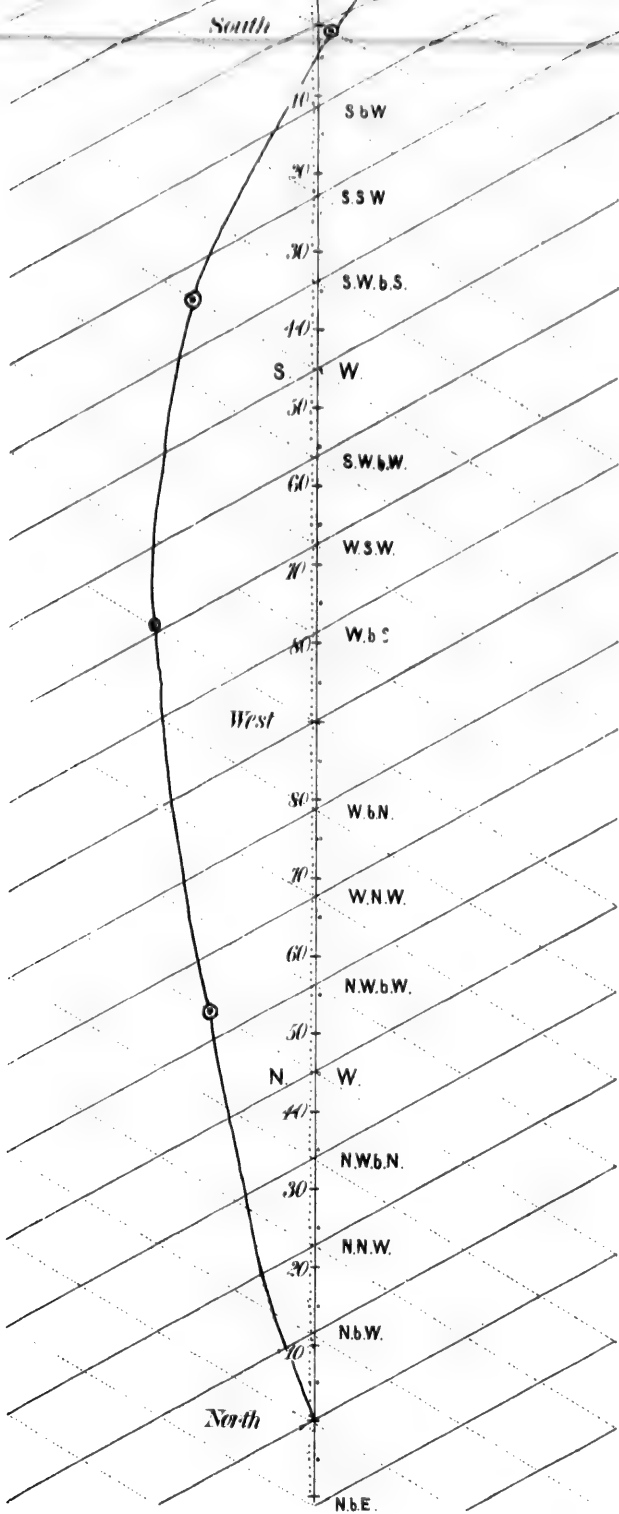
Showing curve of deviations.

Ship...

West Deviation

East Deviation





Capt. R. Connolly.

N. and W., 125 40
N. and E., — 8 00

Head at N. E.,
Cor. Mag. bearing N. 14 43 W

PAPER FIRST.

Multiply 234
By 345

Divide 4567
By 3456

DAY'S WORK.

H.	Courses.	K.	10ths.	Winds.	Lee Way	Deviation.	Remarks.
1	S. 27 30 W.	4	4	S 46 E	15	8 10 W	Lat. left $43^{\circ} 30'$ N., Long. left $66^{\circ} 20'$ W., bearing by Compass N. $30^{\circ} 30'$ W., Dist 15 miles.
2		4	5				
3		4	6				
4		4	5				
5	N. 44 E.	5	5	S 60 E	20	12 E	
6		5	5				Deviation as per Log.
7		4	6				
8		4	4				
9	S. 25 E.	3	3	E	10	4 W	
10		3	7				
11		4	3				Variation 19° W.
12		5	7				
1	S. 10 E.	3	6	S 85 E	13	2 W	
2		3	6				
3		4	4				
4		4	4				Current set (cor. Mag.) N. $60'$ E. 12 miles during the 24 hours.
5	S. 1 W.	5	8	S 65 E		0 40 W	
6		5	4				
7		6	6				
8		6	2				
9	S. 45 W.	6	5	S 65 E	0	15 W	
10		6	5				
11		7	5				
12		7	5				

1876. Jan. 1st, in Long. $63^{\circ} 20'$ W., obs. Alt. $\odot$ S., was $33^{\circ} 20' 30''$, Index Cor. — $2' 10''$, height of eye 12 feet. Required the Lat.

In Lat. $44^{\circ} 30''$ N., Departure 40 miles. Required diff. Long.

Lat. A. $43^{\circ} 30'$ N.

Long. A. $66^{\circ} 40'$ W.

Lat. B. $47^{\circ} 20'$ N.

Long. B. $67^{\circ} 50'$ W.

TIDES.

1873, Jan. 2nd, find the time of high water at Bristol and St. John, N. B., Long. 66° W.

AMPLITUDE.

1876, Jan. 3rd. at 7h. 20m. A. M., in Lat. $44^{\circ} 30' N.$, Long. $66^{\circ} 20' W.$, Sun's Mag. Amp. E. $29^{\circ} 30' S.$, var. by Chart $19^{\circ} W.$ Required Deviation.

CHRONOMETER.

1876, Jan. 4th, at 3h. 40m. P. M., Lat. $44^{\circ} 10' N.$, Long. by acct. $75^{\circ} 12'$, obs. Alt. $\odot$ $16^{\circ} 20' 30''$, Index cor. $+ 2' 2''$, height of eye 14 feet, time by Chr. 7h. $20' 20''$, and found to be fast 2m. 41s. 4t. on Dec. 4th, and on Dec. 15th fast 2m. 21s. 8t. Required the Long.

AZIMUTH.

1876, Jan. 5th, 7h. 50m. A. M., mean time, Lat. $48^{\circ} 50' N.$, Long. $75^{\circ} 50' W.$, Sun's Mag. Azimuth S. $57^{\circ} 10' E.$, obs. Alt. $\odot$ $8^{\circ} 40' 10''$, Index cor. $- 1' 50''$, height of eye 16 feet, var. by chart $16^{\circ} 20' W.$ Required Deviation.

EX. MERIDIAN.

1876, Jan. 6th, P. M., Long. $66^{\circ} 10' W.$, obs. Alt. $\odot$ S. $23^{\circ} 20' 30''$, Index Cor. $- 2' 4''$, height of eye 14 feet, time by watch 0h. 30m. 40s., which was fast on app. time 8m. 10s., diff. Long. W. $15^{\circ} 8'$. Required Lat.

STAR.

1876, Jan. 7th, obs. Alt. of Star (Sirius) S. of observer was $38^{\circ} 10'$, height of eye 20 feet. Required the Lat.

DEVIATION.

Ship's Head.	Bearing of Dist. Object.
N.	N. 44 44 W
N. E.	N. 67 57 W
E.	N. 72 15 W
S. E.	N. 61 40 W
S.	N. 54 54 W
S. W.	N. 42 20 W
W.	N. 20 33 W
N. W.	N. 27 50 W

Construct a Napier Curve and correct the following Courses:—

True course given to find Compass, S. $25^{\circ} 30' E.$, and N. $25^{\circ} 30' E.$

Compass course given to find True, S. $67^{\circ} 30' W.$, and N. $67^{\circ} 30' W.$

Suppose you were sailing along shore, and two well known objects were seen bearing N. $2^{\circ} 20' W.$, S. $2^{\circ} 20' W.$, with the ship's head at N. $30^{\circ} E.$, required correct Magnetic bearings.

PAPER SECOND.

Multiply 8974.7
By 49.9

Divide 14.6
By 13.34

DAY'S WORK.

H.	Courses.	K.	10ths.	Winds.	Lee Way	Deviation.	Remarks.
1	N. 10 W.	7	6	W		4 12 E	Lat. left 44° 44' S., Long. left 84° 45 W., bearing of land when departure was taken S. 59° W., Dis. 14 miles.
2		7	6				
3		7	4				
4		6	9				
5	N. 25 E.	5	6	N 45 W	12	3 15 W	
6		5	6				Deviation 8° E.
7		5	5				
8		4	5				
9	N. 40 E.	4	3	N 20 W	14	12 W	
10		4	3				
11		4	6				Variation 9° E.
12		4	5				
1	N. 70 E.	3	4	N 15 E	20	20 W	
2		3	4				
3		3	4				
4		4	4				Current set (cor. Mag.) N. 40° W. 12 miles from the time the departure was taken to the end of the day.
5	N. 40 W.	4	3	N 18 E	18	6 E	
6		4	2				
7		5	3				
8		6	3				
9	N. 12 W.	6	4	N 45 E	6	4 E	
10		6	4				
11		6	4				
12		7	5				

MERIDIAN ALTITUDE.

1876. Feb. 8th, in Long. 120° 40' E., obs. Alt. $\odot$ N., was 49° 10' 20'', Index Cor. — 2' 4'', height of eye 12 feet. Required the Lat.

PARALLEL.

In Lat. 69° 40' S., Departure 427 miles. Required diff. Long.

MERCATOR.

Lat. A. 40° 40' S.

Long. A. 173° 30' E.

Lat. B. 20° 30' N.

Long. B. 146° 40' W.

TIDES.

1873, Feb. 7th, find the time of high water at Penzance and Hi-ide (Japan), Long. 135° E.

AMPLITUDE.

1876, Feb. 9th, at 6h. 20m., Lat. $43^{\circ} 20'$ N., Long. $66^{\circ} 40'$ W., Sun's Mag. Amp. E. $22^{\circ} 30'$ S., var. by Chart $17^{\circ} 30'$ W. Required Deviation.

CHRONOMETER.

1876, Feb. 2nd, at 9h. 59m. A. M., Lat. $54^{\circ} 58'$ N., Long. by acct. 18° E, obs. Alt. $\odot$ $14^{\circ} 20' 10''$, Index cor. $- 15''$, height of eye 15 feet, time by Chr. 9h. $12' 59''$, and found to be slow $50''$, on January 10th, and on January 25th fast 24s. 4t. Required the Long.

AZIMUTH.

1876, Feb. 20th, 4h. 20m. P. M., Lat. $37^{\circ} 59'$ N., Long. $96^{\circ} 50'$ W., Sun's Mag. Azimuth S. $43^{\circ} 10'$ W., obs. Alt. $\odot$ $27^{\circ} 10' 20''$, height of eye 20 feet, var. by chart $12^{\circ} 40'$ W. Required the Deviation.

EX. MERIDIAN.

1876, Feb. 21st, A. M., Long. $106^{\circ} 10'$ W., obs. Alt. $\odot$ was $21^{\circ} 50' 59''$, Index Cor. $+ 1' 2''$, height of eye 21 feet, time by watch 0h. 5m. 50s., and fast 29m. 50s., diff. Long. made E. $30' 2$. Required Lat.

STAR.

1876, Feb. 30, obs. Alt. of Star (Aldebaran) was $29^{\circ} 52' 10''$, Index cor. $\div 4^{\circ} 10' 7''$, height of eye 15 feet. Required the Lat.

Ship's Head.	Bearing of Dist. Object.
N.	S. 40 40 W
N. E.	S. 20 10 W
E.	S. 7 20 W
S. E.	S. 15 30 W
S.	S. 41 30 W
S. W.	S. 66 10 W
W.	S. 72 40 W
N. W.	S. 59 10 W

Construct a Napier Curve and correct the following Courses:—

Correct Magnetic to find Compass, N. $30^{\circ} 30'$ W., S. $50^{\circ} 30'$ E.

Compass to find Correct Magnetic S. $70^{\circ} 26'$ E., N. $87^{\circ} 50'$ W.

Sailing along a well known coast with ship's head at W., bearing of dis. object was

PAPER THIRD.

Multiply 333.3
By 223.3

Divide 6666.6
By 777.77

DAY'S WORK.

H.	Courses.	K.	10ths.	Winds.	Lee Way	Deviation.	Remarks.
1	N. 30 W.	4	6	N 85 W	15	15 E	Lat. left 48° 30' S., Long. left 179° 10' E., bearing by Compass S. 37° 30' W., Dis. 12 miles.
2		4	4				
3		4	2				
4		4	2				
5	N. 10 W.	4	3	N 67 W	10	6 E	Dev. as per Log.
6		4	4				
7		5					
8		5					
9	N. 15 E.	5		N 48 W	12	4 W	Variation 14° E.
10		5	3				
11		4	8				
12		4	8				
1	N. 20 W.	5		N 35 E	4	10 E	
2		5					
3		5					
4		5					
5	N. 10 W.	9		N 45 E	4	6 E	Current set (cor. mag.) S. 30° 30' E., 27 miles during the 24 hours.
6		9	4				
7		9	4				
8		10					
9	N.	10	4	N 56 E	0	2 E	
10		10	6				
11		11					
12		11	8				

MERIDIAN ALTITUDE.

1876. March 17th, in Long. 177° W., obs. Alt. $\odot$ S. was 88° 50' 50'', Index cor. + 3' 50'', height of eye 16 feet. Required the Lat.

PARALLEL.

In Lat. 49° 40' N., 444 miles. Required the diff. Long.

MERCATOR.

Lat. A. 2° 10' N
Lat. B. 15° 40' S.

Long. A. 171° 10' E.
Long. B. 150° 20' W.

TIDES.

1873. March 28th, Find the time of high water at Wick and at Grindstone Island (Bay of Funday), Long. 65° W.

AMPLITUDE.

1876. March 19th, At 6h. 20m., A. M., in Lat. $46^{\circ} 30'$ N., Long. $67^{\circ} 30'$ W., Sun's Mag. Amplitude E. $3^{\circ} 20'$ S., and variation 14° W. Required Deviation.

CHRONOMETER.

1876. March 26th, at 8h. 20m., A. M., Lat 10° S., Long. by acct. $84^{\circ} 50'$ W, obs. Alt. $\odot$ was $30^{\circ} 30' 30''$, Index cor. — $30''$, height of eye 20 feet, time by Chr. 1h. 58m. 58s., which was fast 2h. 2s. 1t. for Greenwich mean noon Jan. 6th, and on Feb. 5th fast 3h. 50s. 4t. Required the Long.

AZIMUTH.

1876. March 26th, at 8h. 10m., A. M., in Lat. $40^{\circ} 50'$ S., Long. $150^{\circ} 30'$ E., the Sun's bearing by Compass S. $104^{\circ} 40' 20''$ E., obs. Alt. $\odot$ was $19^{\circ} 20' 30''$, height of eye 14 feet, Var. $14^{\circ} 30'$ E. Required Deviation.

EX. MERIDIAN.

1876. March 19th, A. M., Long. $135^{\circ} 30'$ E., obs. Alt. $\odot$ S. $43^{\circ} 40' 20''$, Index Cor. — $1' 4''$, height of eye 19 feet, time by watch 3h. 40m. 20s., and fast 4h. 10m. 30s., diff. of Long. made E. $38' 4t$. Required Lat.

STAR.

1876. March 19th, obs. Alt. of Star (Arcturus) $30^{\circ} 40' 20''$ bearing N., Index Cor. — $3' 2''$, eye 21 feet. Required Lat.

DEVIATION.

Ship's Head.	Bearing of Dis. Object.	Construct a Napier Curve and correct the following courses:—
N.	S. 43 20 E.	True course to find Compass N. 33° W., —S. $86^{\circ} 40'$ W.
N. E.	S. 66 30 E.	
E.	S. 71 40 E.	Compass course to find true N. $80^{\circ} 30''$ E.,—N. $40^{\circ} 30''$ E.
S. E.	S. 60 30 E.	
S.	S. 53 50 E.	Suppose you were sailing up the Bay of Funday and the ship's head at E., and Partridge Island in one with Fort Howe, bearing N. $20^{\circ} 30'$ E. Required Deviation.
S. W.	S. 41 10 E.	
W.	S. 19 30 E.	
N. W.	S. 26 30 E.	

PAPER FOURTH.

Multiply 4444.4
By 333.3

Divide 55555.5
By 5555.5

DAY'S WORK.

H.	Course.	K.	10ths.	Winds.	Lee Way	Devi- ation.	Remarks.
1	N. 70 W.	4	3	N 15 W	20	21 30 E	Lat. left 42° 40' N., Long. left 61° 20' W., bearing by Compass S. 70° 30' W., dis. 12 miles.
2		4	4				
3		4	5				
4		4	6				
5	N. 30 E.	4	6	N 35 W	10	10 20 W	Deviation as per Log.
6		5	7				
7		5	5				
8		4	6				
9	N. 40 E.	4	7	N 16 W	10	22 W	Var. 30° 30' W.
10		4	8				
11		4	6				
12		3	8				
1	N. 80 E.	2	8	N 30 E	29	27 W	Current (correct Mag.) S. 70' E., 19 miles during the 24 hours.
2		2	8				
3		3	4				
4		4	6				
5	N. 25 E.	5	4	N 30 W	18	12 30 W	
6		5	6				
7		5	6				
8		5	6				
9	N. 20 W.	6		N 75 W	25	6 10 E	
10		6					
11		6	5				
12		6	8				

MERIDIAN ALTITUDE.

1876. April 10th, in Long. 80° 20' W., the obs. Alt. ☉ was 33° 22' S., Index Cor. ÷ 4' 3'', height of eye 12 feet. Required Lat.

PARALLEL.

In Lat. 43° 50' N., Dep. made good was 134 miles. Required diff. Long.

MERCATOR.

Lat. A. 20 10 N.
Lat. B. 30 40 S.

Long. A. 160 30 W.
Long. B. 132 50 E.

TIDES.

1873, April 26th, find the time of high water at Anticosti Island, Long. 64d. W., and Banjowangie (China) Long. 145d. E.

AMPLITUDE.

1876, April 10th, at 4h. 20m., A. M., in Lat. 70d. 30m. N., Long. 108d. 50m. W., the Sun's Mag. Amp. E. 4d. 20m. N., and var. 10d. 20m. W. Required Deviation.

CHRONOMETER.

1876, April 20th, at 4h. 10m. P. M., in Lat. 2d. 20m. N., Long. by acct. 178d. E., obs. Alt. ☉ 31d. 59m. 59s., Index Cor. ÷ 2m. 10s., height of eye 16 feet, time by Chr. 3h. 48m. 8s., which was fast 6m. 4s. 2t. on Nov. 10th, and on Jan. 6th fast 3m. 5s. 8t. Required the Long.

AZIMUTH.

1876, April 10th, at 4h. 10m., P. M., in Lat. 52d. 10m. N., Long. 171d. 10m. E., Sun's Mag. Azimuth S. 79d. 50m. W., obs. Alt. ☉ 10d. 20m., height of eye 21 feet, and variation to be 10d. 20m. E. Required Deviation.

EX. MERIDIAN.

1876, April 30th, A. M., Long. 59d. 59m. W., obs. Alt. ☉ S. was 47d. 47m. 20s., Index Cor. + 2m. 4s., height of eye 19 feet, time by watch 0h. 50m. 59s., which was fast 1h. 10m. 15s., diff. Long. made to the E. since the watch was regulated 19m. 5s. Required the Lat.

Ship's Head.	Bearing of Dis. Object.	Construct a Napier Curve, and correct the following courses :
N.	S. 2 10 E	True to find Compass, N. 30d. 30m. E., S. 48d. 30m. W.
N. E.	S. 1 20 W	Compass to find True, S. 60d. 30m. W., S. 10d. 10m. W.
E.	S. 9 30 W	
S. E.	S. 12 10 W	Suppose you were sailing along a well-known coast with the ship's head at N.
S.	S. 1 10 W	33d. E., the bearing of dist. object S.
S. W.	S. 12 20 E	20d. 30m. E., and N. 10d. 40m, W. Re-
W.	S. 14 00 E	quired true bearing.
N. W.	S. 6 30 E	

PAPER FIFTH.

Multiply 484.897
By 337.579

Divide 8888.74
By 7777.33

DAY'S WORK.

H.	Courses.	K.	10ths.	Winds.	Lee Way	Devi- ation.	Remarks.
1	N. 80 E.	6	3	N 20 E	12	23 E	Departure taken from a point of land in Lat. 40d. 40m. N., and in Long. 40d. 40m. W.
2		6	3				
3		6	3				
4		6	3				
5	N. 60 E.	3	9	North.	23	20 E	Bearing by compass S. 40d. 40m. W.
6		3	9				
7		3	2				
8		3	5				
9	N. 30 E.	3	9	E.	20	4 E	Dist. 10 miles.
10		3	9				
11		3	4				
12		3	3				
1	N. 1 W.	8	4	E.	0	2 30 E	Deviation, 10d. 10m. W.
2		8	4				
3		9	6				
4		10	4				
5	N. 4 E.	5	9	N 60 W	5	3 E	Variation 15 W.
6		5	9				
7		4	4				
8		3	6				
9	N. 62 E.	3	2	N 3 E	25	19 E	Current set (correct magnetic), S. 88d. E., 30 miles during the whole 24 hours.
10		3	2				
11		3	2				
12		3	3				

MERIDIAN ALTITUDE.

1876. May 13th, in Long. 51d. 40m. W., obs. Alt. $\odot$ S. was 81d. 10m. 40s., Index error + 4m. 2s., height of eye 18 feet. Required the Latitude.

PARALLEL.

In the Lat. 64d. 20m. N., Departure was 189 miles. Required diff. Longitude.

MERCATOR.

Lat. A, 47 47 N.
Lat. B, 57 57 N.

Long. A, 44 44 W.
Long. B, 64 44 W.

TIDES.

1873, May 22nd. Find the time of high water at H. D'Yew, and Batoo Barra (Sumatra), Long. 95d. E.

AMPLITUDE.

1876, May 28th, at 8h. 10m. A. M., Lat. 56d. 58m. S., Long. 41d. 30m. E., Sun's bearing by compass E. 2d. 49m. S., Variation 28d. W. Required Deviation.

CHRONOMETER.

1876, May 20th, at 3h. 10m. P. M., Lat. 19d. 50m. N., Long. by acct. 141d. 59m. E., obs. Alt. $\odot$ 39d. 10m. 20s., Index cor. — 2m. 10s., height of eye 21 feet, time by Chron. 6h. 12m. 59s., which was fast 2m. 10s. Jan. 2nd, and on Feb. 22nd fast 3m. 20s. 4t. Required the Long. at the time of observation.

AZIMUTH.

1876, May 21st, at 9h. 10m. 20s. A. M., Lat. 53d. 59m. N., Long. 12d. 30m. E., Sun's Mag. Azimuth was S. 58d. 20m. E., obs. Alt. $\odot$ 53d. 10m. 30s., height of eye 22 feet, variation by chart 13d. 10m. W. Required the Deviation.

EX. MERIDIAN.

1876, May 20th, P. M., Long. 100d. 30m. W., obs. Alt. $\odot$ was 41d. 12m. 10s. S., Index cor. + 2m. 4s., height of eye 17 feet, time by watch 6h. 40m. 20s., which was fast 6h. 20m. 40s. for app. time, diff. Long. made E. 35 miles. Required Lat.

STAR.

1876, May 18th, obs. Alt. of Star a Hydræ was 28d. 58m. 48s. S., Index cor. ÷ 2m. 30s., height of eye 19 feet. Required the Latitude.

DEVIATION.

Ship's Head.	Bearing of Dis. Object.	Construct a Napier Curve and correct the following courses:—
N.	N. 53 20 W	True course to find compass N. 29d. 30m.
N. E.	N. 39 00 W	E., S. 51d. 10m. W.
E.	N. 23 30 W	Compass course to find true S. 79d. 40m.
S. E.	N. 17 40 W	E., N. 87d. 50m. W.
S.	N. 32 20 W	Ship's head at N. 45d. E.
S. W.	N. 53 10 W	Bearing of dist. object N. 2d. 10m. W.,
W.	N. 61 40 W	S. 32d. 20m. W.
N. W.	N. 58 20 W	

PAPER SIXTH.

Multiply 4567·8
By 5678·9

Divide 7896·4
By 3456·7

DAY'S WORK.

H.	Courses.	K.	10ths.	Winds.	Lee Way	Deviation.	Remarks.
1	N. 25 E.	9	7	N 78 E	9	14 E	Lat. left 40° 20' N., Long. left 81° 50 W., bearing by Compass N. 51° W. Dis. 14 miles.
2		8	9				
3		7	9				
4		9	4				
5	N. 65 30 E.	4	4	N 7 E	9	16 50 E	
6		4	6				Deviation 9° W.
7		5	4				
8		5	9				
9	N. 3 30 E.	5	4	N 66 E	7 30	5 E	
10		5	8				
11		6					Variation 17° W.
12		6					
1	N. 43 30 E.	7	4	N 15 W	9	16 30 E	
2		7	5				
3		7	7				
4		8	9				Current set (cor. Mag.) N. 57° 30 E. 27 miles for the whole 24 hours.
5	N. 78 30 E.	9	5	N 28 E	10 30	16 50 E	
6		9	5				
7		10	3				
8		10	3				
9	N. 36 E.	10	6	S 45 E	0	5 E	
10		11					
11		11	4				
12		12	8				

MERIDIAN ALTITUDE.

1876. June 12th, Long. 59° 45' E., obs. Alt. $\odot$ N., was 44° 20' 30'', Index Cor. — 3' 10'', height of eye 19 feet. Required the Lat.

PARALLEL.

In Lat. 44° 20' N., Long. 178° 20' W., Departure made good was 230 miles W. Required the Long.

MERCATOR.

Lat. A. 39° 39' N.

Long. A. 170° 10' E.

Lat. B. 14° 14' S.

Long. B. 165° 35' W.

TIDES.

1873, June 17th, required the A. M. and P. M. tides at Hellevoetsliis and Wangaruru (New Zealand), Long. 174° E.

AMPLITUDE.

1876, June 3rd, at 4h. 2m., P. M., Lat. $53^{\circ} 10'$ S., Long. $25^{\circ} 10'$ W., Sun's Mag. Amp. was N. $54^{\circ} 50'$ W., var. $6^{\circ} 1'$ W. Required the Deviation.

CHRONOMETER.

1876, June 20th, at 8h. 45m. A. M., Lat. $15^{\circ} 20'$ N., Long. by acct. $35^{\circ} 50'$ E, obs. Alt. $\odot$ was $38^{\circ} 50' 59''$, Index cor. — $15''$, height of eye 19 feet, time by Chr. 6h. $2' 4''$, which was slow 6m. 2s. 1t. on April 15th, and on May 20th slow 3m. 5s. 7t. Required the Long.

AZIMUTH.

1876, June 26th, at 3h. 35m. P. M., Lat. $61^{\circ} 50'$ N., Long. $66^{\circ} 10'$ W., Sun's Mag. Azimuth was N. 17° E., the obs. Alt. $\odot$ $16^{\circ} 50' 40''$, height of eye 21 feet, var. by chart $57^{\circ} 30'$ W. Required the Deviation.

EX. MERIDIAN.

1876, June 6th, P. M., Long. $144^{\circ} 44'$ E., obs. Alt. $\odot$ S. was $50^{\circ} 9' 20''$, Index Cor. — $1' 20''$, height of eye 19 feet, time by watch 11h. 47m. 30s., and found to be slow 40m. 50s., diff. Long. made W. $18' 4$. Required Lat.

STAR.

1876, June 20, obs. Alt. of Star a Eridana (Achernar) was $47^{\circ} 10' 14''$, Index cor. — 4m. 7s., height of eye 19 feet. Required the Lat.

DEVIATION.

Ship's Head.	Bearing of Dist.Object.
N.	N. 2 10 E
N. E.	N. 13 5 W
E.	N. 15 W
S. E.	N. 8 10 W
S.	N. 3 10 W
S. W.	N. 2 5 E
W.	N. 10 10 E
N. W.	N. 13 E

Construct a Napier Curve and correct the following Courses:—

True course to find Compass, N. 49° E., S. 78° W.

Compass course to find true S. $30^{\circ} 40''$ W., N. $10^{\circ} 30'$ E.

Sailing along shore you took the bearing of two distant objects with the ship's head at E. S. E., find correct Magnetic bearing N. $30^{\circ} 30'$ E., S. $50^{\circ} 50'$ W.

PAPER SEVENTH.

Multiply 87.4444

By 899.9999

Divide 888.777

By 77.666

DAY'S WORK.

H.	Courses.	K.	10ths.	Winds.	Lee Way	Deviation.	Remarks.
1	N. 67 W.	5	5	N 8 W	20	18 E	Lat. left $51^{\circ} 25'$
2		5	5				.N, Long. left 9°
3		5	4				$29'$ W., bearing by
4		5	4				Compass N. $22^{\circ} 30'$
5	N. 68 W.	4	8	N 6 W	17	19 E	E., Dis. 10 miles.
6		4	6				
7		4	4				Dev. as per Log.
8		4					
9	N. 70 W.	4		N 15 W	19	20 E	Variation 25° W.
10		3	6				
11		3	2				
12		3					
1	S. 80 W.	3	4	S 20 W	10	15 E	
2		3	8				
3		4					
4		4					
5	S. 75 W.	4	4	S 16 W	15	10 E	Current set (cor.
6		4	6				mag.) S. 24° W.,
7		5	5				15 miles during the
8		6					24 hours.
9	N. 89 W.	6	2	S 40 W	3	20 E	
10		6	2				
11		6	4				
12		6	6				

MERIDIAN ALTITUDE.

1876. July 20th, Long. $87^{\circ} 30'$ E., obs. Alt. $\odot$ S. was $69^{\circ} 20' 30''$ S., Index error — $1' 15''$, height of eye 19 feet. Required the Lat.

PARALLEL.

In Lat. 62° , departure made $84\frac{1}{8}$. Required diff. Long.

MEL. TOR.

Lat. A. $61^{\circ} 13'$ S.Lat. B. $43^{\circ} 21'$ N.Long. A. $66^{\circ} 34'$ W.Long. B. $19^{\circ} 51'$ E.

TIDES.

1873, July 29th, find A. M. and P. M. tides at Quilleboeuf and Hokianga (New Zealand), Long. 175° E.

AMPLITUDE.

1876, July 31st, at 8h. 20m., A. M., in Lat. $39^{\circ} 10'$ N., Long. $152^{\circ} 30'$ E., Sun's Mag. Amplitude was E. $14^{\circ} 30'$ S., variation $38^{\circ} 10'$ W. Required Deviation.

CHRONOMETER.

1876, July 24th, about 9h. 50m., A. M., Lat $24^{\circ} 50'$ S., Long. by acct. 165° W., obs. Alt. $\odot$ was $28^{\circ} 59' 59''$, Index cor. — $4' 51''$, height of eye 14 feet, time by Chr. 8h. 17m. 59s., which was fast 3m. 2s. 4t. on May 29th, and slow 1m. 25s. 8t. on June 30th. Required the Long.

AZIMUTH.

1876, July 31st, at 7h. 50m., A. M., in Lat. $22^{\circ} 50'$ S., Long. $49^{\circ} 50'$ E., the Magnetic Azimuth was E. $42^{\circ} 20'$ N., obs. Alt. $\odot$ was $46^{\circ} 59' 40''$, Index cor. + 3m. 52s., height of eye 19 feet, and the var. by chart $7^{\circ} 30'$ W. Required the Deviation.

EX. MERIDIAN.

1876, July 29th, P. M., Long. $30^{\circ} 10'$ W., obs. Alt. $\odot$ S. was $41^{\circ} 20' 30''$, Index cor. — $3' 20''$, height of eye 15 feet, time by watch 11h. 50m. 20s., which was slow 38m. 50s., diff. Long. made to the E. was 33 miles. Required the Lat.

STAR.

1876, July 10th, obs. Alt. of Star (Alderbaran) bearing S. was $48^{\circ} 20' 30''$, Index cor. + $2' 10''$, height of eye 22 feet. Required the Lat.

DEVIATION.

Ship's Head.	Bearing of Dis. Object.
N.	N. 13 E.
N. E.	N. 5 E.
E.	N. 6 W.
S. E.	N. 5 E.
S.	N. 13 E.
S. W.	N. 20 E.
W.	N. 21 E.
N. W.	N. 18 E.

Construct a Napier Curve and correct the following courses:—

True course to find Compass N. $76^{\circ} 30'$ E.,—S. $76^{\circ} 30'$ W.

Compass course to find true S. $22^{\circ} 30'$ E.,—N. $22^{\circ} 30'$ W.

Sailing along a well known coast two distant objects bore by Compass N. $25^{\circ} 30'$ E., S. $76^{\circ} 50''$ W., ship's head at S. 30° W., find Cor. Mag. bearings.

PAPER EIGHTH.

Multiply 7777.3

By 888.44

Divide 66777.33

By 55666.22

DAY'S WORK.

H.	Course.	K.	10ths.	Winds.	Lee Way	Deviation.	Remarks.
1	S. 33 E.	3	4	N 67 E	9	14 E	Lat. left $14^{\circ} 30'$ N., Long. left $177^{\circ} 20'$ E., bearing by Compass N. $67^{\circ} 30'$ W., dis. 13 miles.
2		3	4				
3		3	5				
4		3	5				
5	S. 58 W.	3	4	S 20 E	41	18 W	
6		3	3				
7		2					
8		2					
9	S. 29 E.	2	4	N 70 E	39	12 E	Deviation 14° E.
10		2	4				
11		3					
12		3	4				
1	N. 68 W.	4		E	25	17 W	Var. 9° W.
2		4					
3		5	4				
4		5	9				
5	N. 35 W.	6		N 25 E	13	18 W	Current set (cor. Mag.) S. $33^{\circ} 45'$ E., 31 miles during 24 hours.
6		6					
7		7	4				
8		7	4				
9	S. 24 W.	7		S 36 E	4	10 W	
10		7					
11		7	3				
12		7	3				

MERIDIAN ALTITUDE.

1876, August 20th, Long. $125^{\circ} 20'$ E., obs. Alt. of $\odot$ was S. $51^{\circ} 35' 40''$, Index Cor. + $1^{\circ} 40'$, height of eye 21 feet. Required the Lat.

PARALLEL.

In Lat. $69^{\circ} 50'$, Dep. made good was 135 miles. Required diff. Long.

MERCATOR.

Lat. A. 34 50 N.

Lat. B. 42 20 N.

Long. A. 158 30 E.

Long. B. 59 59 W.

TIDES.

1873, August 19th, required the A. M. and P. M. tides at Cardigan and Tracadie, Long. 64d. W.

AMPLITUDE.

1876, August 25th, at 6h. 30m., A. M., in Lat. 47d. 30m. N., Long. 12d. 15m. W., Sun's Mag. Amp. was E. 5d. 30m. S., and var. 29d. W. Required Deviation.

CHRONOMETER.

1876, August 15th, at 7h. 20m. A. M., in Lat. 39d. 59m. S., Long. by acct. 12d. 59m. W., obs. Alt. of ☉ was 10d. 38m. 50s., height of eye 19 feet, Index Cor. — 3m. 10s., time by Chr. 8h. 59m. 10s., which was fast 0h. 2m. 30s. 4t. May 11th, and fast 1m. 29s. on June 29th. Required the Long.

AZIMUTH.

1876, August 19th, at 8h. 50m., A. M., in Lat. 19d. 50m. S., Long. 47d. 30m. E., Sun's bearing by Compass E. 37d. 50m. N., obs. Alt. ☉ was 46d. 59m. 59s., Index Cor. + 2m. 3s., height of eye 17 feet, and variation 17d. 20m. W. Required Deviation.

EX. MERIDIAN.

1876, August 2nd, P. M., Long. 42d. 20m. W., obs. Alt. ☉ S. was 41d. 20m. 30s., Index Cor. + 2m. 10s., height of eye 13 feet, time by watch 11h. 30m. 20s., which was slow 1h. 10m. 10s. on apparent time, and the diff. of Long. made to the W. 27 miles. Required the Lat.

STAR.

1876, August 31st, obs. Alt. of Star Orionis (Rigel) was 43d. 47m. 20s. bearing N., Index Cor. + 3m. 2s., height of eye 14 feet. Required the Lat.

DEVIATION.

Ship's Head.	Bearing of Dis. Object.	Construct a Napier Curve, and correct the following courses :
N.	N. 83 20 W	True to find Compass. N. 19d. 40m. W., S. 77d. 20m. E.
N. E.	N. 71 50 W	
E.	N. 53 10 W	Compass to find True, S. 19d. 40m. E., N. 69d. 30m. W.
S. E.	N. 48 15 W	
S.	N. 63 40 W	Ship's head S. 35d. E., bearing of distant objects N. 10d. 15m. E., S. 37d. 20m. W.
S. W.	N. 83 10 W	
W.	N. 81 40 W	
N. W.	N. 83 50 W	

PAPER NINTH.

Multiply 494.22
By 375.89.

Divide 4876.43
By 320.44

DAY'S WORK.

H.	Courses.	K.	10ths.	Winds.	Lee Way	Deviation.	Remarks.
1	N.	6	4	N 67 W	11	3 30 E	Lat. left 50° 50' N., Long left 140° 30' W., bearing by Compass S. 45° W. Dist. 18 miles.
2		6	4				
3		6	4				
4		6	4				
5	N. 11 E.	6	8	N 56 W	14	4 20 E	
6		6	8				Deviation as per Log.
7		6	8				
8		6	9				
9	N. 56 E.	7	2	N 11 W	5	10 E	
10		7	3				
11		7	5				Var. 25° 19' W.
12		7	7				
1	N. 67 E.	7	7	N.	9	18 E	
2		7	8				
3		7	9				
4		6	8				Current set (correct magnetic), N. 45d. E., 20 miles during the whole 24 hours.
5	N. 78 E.	6	4	N 12 E	17	19 E	
6		6	6				
7		6	6				
8		6	4				
9	N. 22 W.	5	8	N 40 E	15	4 W	
10		5	8				
11		5	8				
12		5					

MERIDIAN ALTITUDE.

1876, Sept. 23rd, in Long. 160d. 40m. E., obs. Alt. $\odot$ S. was 42d. 20m. 30s., correct — 2m. 10s., height of eye 20 feet.

PARALLEL.

In Lat. 59d. 50m. N., Departure made good was 139.8. Required diff. Longitude.

MERCATOR.

Lat. A, 23 10 N.
Lat. B, 10 20 S.

Long. A, 159 30 E.
Long. B, 179 20 W.

TIDES.

1873, Sept. 14th, Find the time of high water at Wells Bar and Tutukaka, Long. 134d. E.

AMPLITUDE.

1876, Sept. 9th, at 5h. 50m. A. M., Lat. 25d. 10m. N., Long. 57d. 30m. W., Sun's Magnetic Amplitude E., var. by Chart 5d. 50m. W. Required the Deviation.

CHRONOMETER.

1876, Sept. 2nd, at 2h. 10m. P. M., Lat. 10d. 12m. N., Long. by acct. 130d. E., obs. Alt. $\odot$ was 61d. 59m. 40s., Index cor. — 1m. 20s., height of eye 19 feet, time by Chron. 5h. 10m. 4s., and found to be fast 1m. 4s. 2t. on Aug. 10th, and on Aug. 20th fast 0m. 40s. 3t. Required the Long.

AZIMUTH.

1876, Sept. 2nd, at 3h. 48m. 10s. P. M., mean time Lat. 11d. 30m. S., Long. 140d. 20m. E., Mag. Azimuth N. 80d. 30m. W., obs. Alt. 34d. 10m. 00s., height of eye 19 feet, variation by chart 4d. 40m. W. Required Deviation for ship's head.

EX. MERIDIAN.

1876, Sept. 10th, P. M., Long. 177d 59m. 50s. E., obs. Alt. $\odot$ was 63d. 10m. 40s. S., height of eye 16 feet, time by watch 11h. 58m. 20s., which was slow 10m. 4s., diff. Long. made E. 12m. 2s. Required the Lat.

STAR.

1876, Sept. 20th, obs. Alt. of Star (Regulus) 61d. 20m. 30s., Index cor. — 2m. 10s., height of eye 22 feet. Required the Latitude.

DEVIATION.

Ship's Head.	Bearing of Dis. Object.	Construct a Napier Curve and correct the following courses:—
N.	N. 3 30 E	True course given to find compass N. 60d. W., S. 40d. E.
N. E.	N. 15 20 W	Compass course given to find true S. 27d. W., N. 80d. E.
E.	N. 17 10 W	Suppose you were sailing along a well known coast, and two objects were seen in one, with the ship's head at N. 50d. W. Required the Deviation for the ship's head, N. 20d. 30m. E., N. 67d. 40m. W.
S. E.	N. 10 30 W	
S.	N. 5 30 W	
S. W.	N. 4 10 E	
W.	N. 12 20 E	
N. W.	N. 15 30 E	

JANUARY, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be added to Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	S. 23 2 36.4	12.05	3 38.54	1.190	S. 23 2 37.1	16 18.2
2	22 57 33.5	13.20	4 6.92	1.175	22 57 34.4	16 18.2
3	22 52 3.1	14.34	4 34.94	1.159	22 52 4.2	16 18.2
4	22 46 5.4	15.47	5 2.56	1.142	22 46 6.7	16 18.2
5	22 39 40.6	16.59	5 29.76	1.124	22 39 42.1	16 18.2
6	22 32 48.9	17.71	5 56.49	1.104	22 32 50.6	16 18.2
7	22 25 30.5	18.82	6 22.75	1.084	22 25 32.5	16 18.2
8	22 17 45.7	19.91	6 48.50	1.062	22 17 48.0	16 18.1
9	22 9 34.7	21.00	7 13.72	1.039	22 9 37.2	16 18.1
10	22 0 57.7	22.08	7 38.39	1.016	22 1 0.5	16 18.1
11	21 51 55.0	23.14	8 2.49	0.992	21 51 58.1	16 18.0
12	21 42 26.9	24.19	8 26.00	0.967	21 42 30.3	16 18.0
13	21 32 33.6	25.24	8 48.91	0.941	21 32 37.3	16 17.9
14	21 22 15.2	26.28	9 11.19	0.915	21 22 19.2	16 17.8
15	21 11 32.2	27.30	9 32.83	0.888	21 11 36.5	16 17.8
16	21 0 24.8	28.31	9 53.81	0.860	21 0 29.4	16 17.7
17	20 48 53.2	29.31	10 14.12	0.832	20 48 58.2	16 17.6
18	20 36 57.8	30.30	10 33.79	0.803	20 37 3.2	16 17.5
19	20 24 38.9	31.27	10 52.69	0.774	20 24 44.6	16 17.4
20	20 11 56.9	32.23	11 10.89	0.744	20 12 2.9	16 17.3
21	19 58 52.1	33.17	11 28.37	0.713	19 58 58.5	16 17.2
22	19 45 24.8	34.10	11 45.10	0.681	19 45 31.5	16 17.1
23	19 31 35.5	35.01	12 1.08	0.649	19 31 42.5	16 17.0
24	19 17 24.5	35.90	12 16.28	0.617	19 17 31.8	16 16.9
25	19 2 52.1	36.79	12 30.69	0.584	19 2 59.7	16 16.8
26	18 47 58.7	37.65	12 44.30	0.550	18 48 6.7	16 16.7
27	18 32 44.9	38.50	12 57.10	0.516	18 32 53.2	16 16.6
28	18 17 10.9	39.33	13 9.08	0.482	18 17 19.5	16 16.4
29	18 1 17.2	40.14	13 20.24	0.447	18 1 26.1	16 16.3
30	17 45 4.1	40.94	13 30.56	0.413	17 45 13.3	16 16.2
31	17 28 32.1	41.72	13 40.05	0.378	17 28 41.6	16 16.0
32	S. 17 11 41.6	42.48	13 48.69	0.343	S. 17 11 51.4	16 15.9

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

FEBRUARY, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S			Equation of Time to be added to Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S		
	Apparent Declination.		Var. in 1 hour.			Apparent Declination.		Semi- diameter.*
	°	' "	"			in s	s	°
1	S	17 11 41·6	42·48	13 48·69	0·343	S	17 11 51·4	16 15·9
2		16 54 33·1	43·22	13 56·50	0·308		16 54 43·1	16 15·7
3		16 37 6·9	43·95	14 3·47	0·273		16 37 17·2	16 15·6
4		16 19 23·5	44·66	14 9·60	0·238		16 19 34·0	16 15·4
5		16 1 23·3	45·35	14 14·89	0·203		16 1 34·0	16 15·3
6		15 43 6·7	46·02	14 19·35	0·169		15 43 17·7	16 15·1
7		15 24 34·2	46·68	14 22·99	0·135		15 24 45·4	16 15·0
8		15 5 46·1	47·32	14 25·81	0·101		15 5 57·5	16 14·8
9		14 46 42·8	47·94	14 27·83	0·068		14 46 54·4	16 14·6
10		14 27 24·8	48·55	14 29·06	0·035		14 27 36·5	16 14·4
11		14 7 52·4	49·14	14 29·51	0·003		14 8 4·3	16 14·2
12		13 48 5·9	49·72	14 29·19	0·029		13 48 17·9	16 14·0
13		13 28 5·8	50·28	14 28·12	0·060		13 28 17·9	16 13·8
14		13 7 52·4	50·82	14 26·31	0·091		13 8 4·7	16 13·6
15		12 47 26·2	51·35	14 23·77	0·120		12 47 38·5	16 13·4
16		12 26 47·5	51·86	14 20·53	0·150		12 26 59·9	16 13·2
17		12 5 56·8	52·36	14 16·58	0·179		12 6 9·2	16 13·0
18		11 44 54·4	52·83	14 11·95	0·207		11 45 6·9	16 12·8
19		11 23 40·8	53·29	14 6·64	0·235		11 23 53·4	16 12·6
20		11 2 16·5	53·73	14 0·67	0·262		11 2 29·0	16 12·4
21		10 40 41·7	54·15	13 54·05	0·289		10 40 54·3	16 12·1
22		10 18 57·1	54·56	13 46·78	0·316		10 19 9·6	16 11·9
23		9 57 2·9	54·95	13 38·88	0·342		9 57 15·4	16 11·7
24		9 34 59·6	55·32	13 30·37	0·367		9 35 12·0	16 11·5
25		9 12 47·6	55·67	13 21·26	0·392		9 13 0·0	16 11·2
26		8 50 27·4	56·00	13 11·57	0·416		8 50 39·7	16 11·0
27		8 27 59·4	56·32	13 1·29	0·440		8 28 11·6	16 10·7
28		8 5 24·0	56·62	12 50·45	0·463		8 5 36·1	16 10·5
29		7 42 41·6	56·90	12 39·07	0·485		7 42 53·6	16 10·3
30	S	7 19 52·6	57·17	12 27·16	0·507	S	7 20 4·5	16 10·0

* The Semidiameter for *Apparent* Noon may be assumed the same as that for *Mean* Noon.

MARCH, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S			Equation of Time to be added to Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S						
	Apparent Declination.		Var. in 1 hour.			Apparent Declination.		Semi- diameter.*				
	°	'	"	"	m	s	°	'	"	'	"	
1	S.	7	19	52.6	57.17	12	27.16	0.507	S.	7	20 4.5	16 10.0
2		6	56	57.6	57.41	12	14.74	0.528		6	57 9.3	16 9.8
3		6	33	56.8	57.64	12	1.82	0.548		6	34 8.3	16 9.6
4		6	10	50.7	57.86	11	48.42	0.568		6	11 2.1	16 9.3
5		5	47	39.6	58.05	11	34.57	0.586		5	47 50.8	16 9.1
6		5	24	24.1	58.23	11	20.28	0.604		5	24 35.1	16 8.8
7		5	1	4.4	58.40	11	5.57	0.621		5	1 15.2	16 8.6
8		4	37	40.9	58.55	10	50.46	0.637		4	37 51.4	16 8.3
9		4	14	13.9	58.69	10	34.98	0.652		4	14 24.2	16 8.0
10		3	50	43.8	58.81	10	19.15	0.666		3	50 53.9	16 7.8
11		3	27	10.9	58.92	10	3.00	0.679		3	27 20.8	16 7.5
12		3	3	35.6	59.02	9	46.56	0.691		3	3 45.2	16 7.2
13		2	39	58.1	59.10	9	29.84	0.702		2	40 7.5	16 7.0
14		2	16	19.0	59.16	9	12.87	0.712		2	16 28.1	16 6.7
15		1	52	38.4	59.21	8	55.67	0.721		1	52 47.3	16 6.4
16		1	28	56.8	59.25	8	38.27	0.729		1	29 5.4	16 6.2
17		1	5	14.5	59.27	8	20.69	0.736		1	5 22.7	16 5.9
18		0	41	31.9	59.28	8	2.94	0.742		0	41 39.8	16 5.6
19	S.	0	17	49.3	59.27	7	45.05	0.748	S.	0	17 56.9	16 5.3
20	N.	0	5	52.9	59.24	7	27.03	0.753	N.	0	5 45.5	16 5.0
21		0	29	34.3	59.20	7	8.91	0.757		0	29 27.2	16 4.8
22		0	53	14.5	59.14	6	50.70	0.760		0	53 7.7	16 4.5
23		1	16	53.2	59.07	6	32.41	0.763		1	16 46.7	16 4.2
24		1	40	29.9	58.98	6	14.08	0.765		1	40 23.8	16 3.9
25		2	4	4.4	58.88	5	55.71	0.766		2	3 58.6	16 3.6
26		2	27	36.2	58.76	5	37.33	0.766		2	27 30.7	16 3.4
27		2	51	4.9	58.62	5	18.95	0.766		2	50 59.7	16 3.1
28		3	14	30.2	58.47	5	0.58	0.765		3	14 25.3	16 2.8
29		3	37	51.7	58.31	4	42.25	0.763		3	37 47.1	16 2.6
30		4	1	9.0	58.13	4	23.97	0.760		4	1 4.7	16 2.3
31		4	24	21.7	57.93	4	5.76	0.757		4	24 17.7	16 2.0
32	N.	4	47	29.5	57.71	3	47.63	0.753	N.	4	47 25.8	16 1.7

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

APRIL, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be added to subt. from Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	N 4 47 29.5	57.71	3 47.63	0.753	N 4 47 25.8	16 1.7
2	5 10 32.0	57.49	3 29.60	0.749	5 10 28.6	16 1.5
3	5 33 28.9	57.25	3 11.69	0.743	5 33 25.8	16 1.2
4	5 56 19.8	56.99	2 53.92	0.737	5 56 17.0	16 0.9
5	6 19 4.4	56.72	2 36.30	0.730	6 19 1.9	16 0.6
6	6 41 42.4	56.44	2 18.87	0.722	6 41 40.2	16 0.4
7	7 4 13.5	56.15	2 1.64	0.713	7 4 11.6	16 0.1
8	7 26 37.4	55.84	1 44.63	0.703	7 26 35.8	15 59.8
9	7 48 53.8	55.52	1 27.88	0.692	7 48 52.5	15 59.6
10	8 11 2.4	55.19	1 11.39	0.681	8 11 1.3	15 59.3
11	8 33 2.8	54.84	0 55.19	0.669	8 33 2.0	15 59.0
12	8 54 54.8	54.48	0 39.30	0.655	8 54 54.2	15 58.7
13	9 16 38.0	54.11	0 23.74	0.641	9 16 37.7	15 58.5
14	9 38 12.1	53.73	0 8.52	0.627	9 38 12.0	15 58.2
15	9 59 36.8	53.33	0 6.34	0.611	9 59 36.9	15 57.9
16	10 20 51.8	52.91	0 20.82	0.595	10 20 52.1	15 57.6
17	10 41 56.6	52.48	0 34.91	0.579	10 41 57.1	15 57.4
18	11 2 51.0	52.04	0 48.60	0.561	11 2 51.7	15 57.1
19	11 23 34.6	51.59	1 1.86	0.543	11 23 35.5	15 56.8
20	11 44 7.1	51.12	1 14.69	0.525	11 44 8.1	15 56.6
21	12 4 28.1	50.63	1 27.08	0.507	12 4 29.3	15 56.3
22	12 24 37.3	50.13	1 39.01	0.487	12 24 38.7	15 56.1
23	12 44 34.3	49.61	1 50.47	0.468	12 44 35.8	15 55.8
24	13 4 18.8	49.08	2 1.46	0.448	13 4 20.5	15 55.5
25	13 23 50.4	48.54	2 11.97	0.428	13 23 52.2	15 55.3
26	13 43 8.8	47.98	2 21.98	0.407	13 43 10.7	15 55.0
27	14 2 13.6	47.41	2 31.50	0.386	14 2 15.6	15 54.8
28	14 21 4.5	46.82	2 40.53	0.366	14 21 6.6	15 54.6
29	14 39 41.2	46.22	2 49.06	0.345	14 39 43.3	15 54.3
30	14 58 3.2	45.61	2 57.08	0.323	14 58 5.4	15 54.1
31	N 15 16 10.3	44.98	3 4.58	0.302	N 15 16 12.6	15 53.9

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

MAY, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be subtr. to Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s s	s	° ' "	' "
1	N.15 16 10.3	44.98	3 4.58	0.302	N.15 16 12.6	15 53.9
2	15 34 2.2	44.34	3 11.57	0.280	15 34 4.6	15 53.7
3	15 51 38.6	43.69	3 18.03	0.258	15 51 41.0	15 53.4
4	16 8 59.2	43.02	3 23.95	0.235	16 9 1.6	15 53.2
5	16 26 3.7	42.34	3 29.33	0.212	16 26 6.1	15 53.0
6	16 42 51.7	41.66	3 34.15	0.189	16 42 54.2	15 52.8
7	16 59 23.2	40.96	3 38.41	0.166	16 59 25.6	15 52.5
8	17 15 37.7	40.25	3 42.11	0.142	17 15 40.1	15 52.3
9	17 31 35.0	39.52	3 45.23	0.118	17 31 37.5	15 52.1
10	17 47 14.8	38.79	3 47.76	0.094	17 47 17.3	15 51.9
11	18 2 36.9	38.05	3 49.72	0.069	18 2 39.3	15 51.7
12	18 17 41.0	37.29	3 51.09	0.045	18 17 43.4	15 51.5
13	18 32 26.7	36.52	3 51.88	0.021	18 32 29.0	15 51.3
14	18 46 53.8	35.73	3 52.08	0.004	18 46 56.1	15 51.1
15	19 1 1.9	34.94	3 51.69	0.028	19 1 4.2	15 50.9
16	19 14 51.0	34.14	3 50.72	0.052	19 14 53.2	15 50.7
17	19 28 20.6	33.32	3 49.17	0.076	19 28 22.7	15 50.5
18	19 41 30.4	32.49	3 47.05	0.100	19 41 32.5	15 50.3
19	19 54 20.3	31.65	3 44.36	0.124	19 54 22.3	15 50.1
20	20 6 49.8	30.80	3 41.10	0.148	20 6 51.7	15 49.9
21	20 18 58.8	29.94	3 37.28	0.171	20 19 0.6	15 49.7
22	20 30 47.0	29.07	3 32.91	0.193	20 30 48.7	15 49.5
23	20 42 14.1	28.19	3 28.01	0.215	20 42 15.8	15 49.4
24	20 53 19.9	27.29	3 22.60	0.236	20 53 21.5	15 49.2
25	21 4 4.1	26.39	3 16.68	0.256	21 4 5.6	15 49.0
26	21 14 26.5	25.48	3 10.29	0.276	21 14 27.9	15 48.9
27	21 24 26.9	24.55	3 3.43	0.295	21 24 28.2	15 48.7
28	21 34 5.0	23.62	2 56.12	0.314	21 34 6.2	15 48.6
29	21 43 20.6	22.68	2 48.38	0.331	21 43 21.7	15 48.5
30	21 52 13.6	21.73	2 40.23	0.348	21 52 14.5	15 48.3
31	22 0 43.7	20.77	2 31.67	0.365	22 0 44.6	15 48.2
32	N.22 8 50.8	19.81	2 22.73	0.380	N.22 8 51.6	15 48.1

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

JUNE, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be subt. from added to Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	N.22 8 50.8	19.81	2 22.73	0.380	N.22 8 51.6	15 48.1
2	22 16 34.7	18.84	2 13.41	0.396	22 16 35.4	15 47.9
3	22 23 54.3	17.87	2 3.73	0.411	22 23 56.0	15 47.8
4	22 30 52.5	16.89	1 53.71	0.425	22 30 53.1	15 47.7
5	22 37 26.1	15.90	1 43.35	0.438	22 37 26.6	15 47.6
6	22 43 35.9	14.91	1 32.68	0.451	22 43 36.3	15 47.5
7	22 49 21.9	13.92	1 21.71	0.463	22 49 22.2	15 47.4
8	22 54 44.0	12.92	1 10.45	0.475	22 54 44.2	15 47.2
9	22 59 42.0	11.91	0 58.93	0.485	22 59 42.1	15 47.1
10	23 4 15.7	10.90	0 47.17	0.495	23 4 15.9	15 47.0
11	23 8 25.2	9.89	0 35.17	0.504	23 8 25.3	15 46.9
12	23 12 10.3	8.87	0 22.96	0.512	23 12 10.4	15 46.8
13	23 15 30.9	7.85	0 10.57	0.520	23 15 31.0	15 46.7
14	23 18 27.0	6.82	0 1.99	0.526	23 18 27.0	15 46.7
15	23 20 58.4	5.79	0 14.69	0.532	23 20 58.4	15 46.6
16	23 23 5.1	4.76	0 27.52	0.537	23 23 5.1	15 46.5
17	23 24 47.0	3.73	0 40.46	0.541	23 24 47.0	15 46.4
18	23 26 4.1	2.70	0 53.48	0.543	23 26 4.1	15 46.4
19	23 26 56.4	1.66	1 6.55	0.545	23 26 56.4	15 46.3
20	23 27 23.9	0.63	1 19.65	0.546	23 27 23.9	15 46.2
21	23 27 26.5	0.41	1 32.75	0.545	23 27 26.5	15 46.2
22	23 27 4.2	1.44	1 45.82	0.543	23 27 4.3	15 46.1
23	23 26 17.1	2.48	1 58.82	0.540	23 26 17.2	15 46.1
24	23 25 5.2	3.51	2 11.72	0.535	23 25 5.4	15 46.1
25	23 23 28.6	4.54	2 24.50	0.529	23 23 28.8	15 46.0
26	23 21 27.2	5.57	2 37.13	0.523	23 21 27.5	15 46.0
27	23 19 1.2	6.59	2 49.59	0.515	23 19 1.5	15 46.0
28	23 16 10.7	7.61	3 1.84	0.506	23 16 11.0	15 46.0
29	23 12 55.7	8.64	3 13.87	0.496	23 12 56.1	15 46.0
30	23 9 16.2	9.65	3 25.67	0.486	23 9 16.8	15 46.0
31	N.23 5 12.5	10.66	3 37.20	0.475	N.23 5 13.2	15 46.0

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

JULY, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be added to Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	N.23 5 12.5	10.66	3 37.20	0.475	N.23 5 13.2	15 46.0
2	23 0 44.7	11.66	3 48.46	0.463	23 0 45.4	15 46.0
3	22 55 52.8	12.66	3 59.42	0.450	22 55 53.6	15 46.0
4	22 50 37.0	13.65	4 10.06	0.436	22 50 38.0	15 46.0
5	22 44 57.4	14.64	4 20.37	0.422	22 44 58.5	15 46.0
6	22 38 54.2	15.62	4 30.34	0.407	22 38 55.3	15 46.0
7	22 32 27.5	16.60	4 39.93	0.392	22 32 28.7	15 46.0
8	22 25 37.4	17.57	4 49.14	0.376	22 25 38.8	15 46.0
9	22 18 24.1	18.54	4 57.96	0.359	22 18 25.6	15 46.1
10	22 10 47.7	19.49	5 6.37	0.342	22 10 49.4	15 46.1
11	22 2 48.5	20.44	5 14.36	0.324	22 2 50.3	15 46.1
12	21 54 26.5	21.39	5 21.91	0.305	21 54 28.4	15 46.2
13	21 45 41.9	22.32	5 29.01	0.286	21 45 44.0	15 46.2
14	21 36 35.0	23.25	5 35.65	0.267	21 36 37.2	15 46.3
15	21 27 5.9	24.17	5 41.82	0.247	21 27 8.2	15 46.3
16	21 17 14.8	25.08	5 47.51	0.227	21 17 17.2	15 46.4
17	21 7 1.9	25.99	5 52.71	0.206	21 7 4.5	15 46.4
18	20 56 27.5	26.88	5 57.39	0.184	20 56 30.2	15 46.5
19	20 45 31.8	27.76	6 1.55	0.162	20 45 34.6	15 46.6
20	20 34 15.1	28.63	6 5.16	0.139	20 34 18.0	15 46.6
21	20 22 37.5	29.49	6 8.22	0.116	20 22 40.5	15 46.7
22	20 10 39.4	30.34	6 10.71	0.092	20 10 42.6	15 46.8
23	19 58 21.1	31.18	6 12.61	0.067	19 58 24.4	15 46.9
24	19 45 42.9	32.00	6 13.91	0.042	19 45 46.2	15 47.0
25	19 32 44.9	32.82	6 14.61	0.016	19 32 48.5	15 47.1
26	19 19 27.5	33.63	6 14.70	0.009	19 19 31.0	15 47.2
27	19 5 50.9	34.42	6 14.18	0.035	19 5 54.5	15 47.3
28	18 51 55.5	35.20	6 13.04	0.060	18 51 59.2	15 47.4
29	18 37 41.5	35.96	6 11.28	0.086	18 37 45.3	15 47.5
30	18 23 9.3	36.72	6 8.90	0.112	18 23 13.1	15 47.7
31	18 8 19.1	37.46	6 5.91	0.137	18 8 22.9	15 47.8
32	N.17 53 11.1	38.20	6 2.30	0.163	N.17 53 15.0	15 47.9

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

AUGUST, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be added to subt. from Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	N. 17 53 11.1	38.20	6 2.30	0.163	N. 17 53 15.0	15 47.9
2	17 37 45.7	38.91	5 58.07	0.189	17 37 49.6	15 48.1
3	17 22 3.3	39.62	5 53.23	0.214	17 22 7.2	15 48.2
4	17 6 3.9	40.32	5 47.79	0.239	17 6 7.8	15 48.3
5	16 49 48.0	41.00	5 41.74	0.264	16 49 51.9	15 48.5
6	16 33 15.8	41.68	5 35.10	0.289	16 33 19.7	15 48.6
7	16 16 27.6	42.34	5 27.87	0.313	16 16 31.5	15 48.8
8	15 59 23.7	42.99	5 20.06	0.337	15 59 27.5	15 48.9
9	15 42 4.2	43.63	5 11.69	0.361	15 42 8.0	15 49.1
10	15 24 29.6	44.25	5 2.75	0.384	15 24 33.3	15 49.3
11	15 6 40.1	44.87	4 53.27	0.406	15 6 43.8	15 49.4
12	14 48 36.0	45.47	4 43.24	0.428	14 48 39.6	15 49.6
13	14 30 17.5	46.06	4 32.69	0.450	14 30 21.0	15 49.7
14	14 11 45.1	46.64	4 21.62	0.472	14 11 48.5	15 49.9
15	13 52 59.0	47.20	4 10.03	0.493	13 53 2.2	15 50.1
16	13 33 59.4	47.75	3 57.94	0.514	13 34 2.6	15 50.3
17	13 14 46.9	48.29	3 45.35	0.535	13 14 49.9	15 50.4
18	12 55 21.7	48.81	3 32.26	0.556	12 55 24.6	15 50.6
19	12 35 44.1	49.32	3 18.68	0.576	12 35 46.8	15 50.8
20	12 15 54.5	49.81	3 4.62	0.596	12 15 57.1	15 51.0
21	11 55 53.3	50.29	2 50.09	0.615	11 55 55.7	15 51.2
22	11 35 40.8	50.75	2 35.09	0.634	11 35 43.0	15 51.4
23	11 15 17.3	51.20	2 19.64	0.653	11 15 19.3	15 51.6
24	10 54 43.1	51.64	2 3.75	0.671	10 54 44.9	15 51.9
25	10 33 58.7	52.06	1 47.43	0.688	10 34 0.3	15 52.1
26	10 13 4.4	52.46	1 30.71	0.705	10 13 5.7	15 52.3
27	9 52 0.4	52.86	1 13.58	0.722	9 52 1.4	15 52.5
28	9 30 47.0	53.24	0 56.07	0.737	9 30 47.9	15 52.8
29	9 9 24.7	53.61	0 38.19	0.752	9 9 25.3	15 53.0
30	8 47 53.8	53.96	0 19.97	0.766	8 47 54.1	15 53.2
31	8 26 14.4	54.31	0 1.41	0.780	8 26 14.4	15 53.4
32	N. 8 4 27.0	54.64	0 17.46	0.793	N. 8 4 26.8	15 53.7

* The Semidiameter for *Apparent* Noon may be assumed the same as that for *Mean* Noon.

SEPTEMBER, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be sub. from Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	N. 8 4 27.0	54.64	0 17.46	0.793	N. 8 4 26.8	15 53.7
2	7 42 31.9	54.95	0 36.63	0.805	7 42 31.4	15 53.9
3	7 20 29.4	55.25	0 56.08	0.815	7 20 28.5	15 54.2
4	6 58 19.7	55.55	1 15.77	0.825	6 58 18.5	15 54.4
5	6 36 3.2	55.83	1 35.70	0.835	6 36 1.7	15 54.6
6	6 13 40.1	56.09	1 55.84	0.843	6 13 38.2	15 54.9
7	5 51 10.7	56.35	2 16.16	0.850	5 51 8.5	15 55.1
8	5 28 35.3	56.59	2 36.65	0.857	5 28 32.9	15 55.4
9	5 5 54.3	56.82	2 57.29	0.862	5 5 51.5	15 55.6
10	4 43 7.9	57.04	3 18.04	0.867	4 43 4.8	15 55.9
11	4 20 16.5	57.24	3 38.89	0.871	4 20 13.0	15 56.1
12	3 57 20.3	57.43	3 59.83	0.874	3 57 16.5	15 56.4
13	3 34 19.8	57.60	4 20.84	0.876	3 34 15.7	15 56.6
14	3 11 15.3	57.76	4 41.89	0.878	3 11 10.8	15 56.9
15	2 48 7.1	57.91	5 2.98	0.879	2 48 2.2	15 57.1
16	2 24 55.6	58.04	5 24.09	0.879	2 24 50.4	15 57.4
17	2 1 41.2	58.15	5 45.19	0.879	2 1 35.6	15 57.6
18	1 38 24.2	58.25	6 6.28	0.878	1 38 18.3	15 57.9
19	1 15 5.0	58.34	6 27.33	0.876	1 14 58.7	15 58.2
20	0 51 44.0	58.41	6 48.33	0.874	0 51 37.3	15 58.4
21	0 28 21.4	58.46	7 9.26	0.870	0 28 14.5	15 58.7
22	N. 0 4 57.8	58.50	7 30.10	0.866	N. 0 4 50.5	15 59.0
23	S. 0 18 26.6	58.53	7 50.84	0.861	S. 0 18 34.3	15 59.3
24	0 41 51.4	58.54	8 11.45	0.856	0 41 59.4	15 59.5
25	1 5 16.3	58.53	8 31.92	0.849	1 5 24.6	15 59.8
26	1 28 40.9	58.51	8 52.22	0.842	1 28 49.5	16 0.1
27	1 52 4.8	58.48	9 12.34	0.834	1 52 13.8	16 0.4
28	2 15 27.8	58.43	9 32.26	0.825	2 15 37.1	16 0.7
29	2 38 49.4	58.37	9 51.95	0.815	2 38 59.0	16 1.0
30	3 2 9.4	58.29	10 11.40	0.805	3 2 19.3	16 1.2
31	S. 3 25 27.4	58.20	10 30.57	0.793	S. 3 25 37.6	16 1.5

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

OCTOBER, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be subt. from Apparent Time.	Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	S. 3 25 27.4	58.20	10 30.57	0.793	S. 3 25 37.6	16 1.5
2	3 48 43.1	58.10	10 49.45	0.780	3 48 53.5	16 1.8
3	4 11 56.1	57.98	11 8.02	0.766	4 12 6.8	16 2.1
4	4 35 6.1	57.85	11 26.24	0.751	4 35 17.2	16 2.3
5	4 58 12.9	57.70	11 44.09	0.736	4 58 24.2	16 2.6
6	5 21 16.0	57.55	12 1.55	0.719	5 21 27.6	16 2.9
7	5 44 15.2	57.38	12 18.59	0.701	5 44 27.0	16 3.2
8	6 7 10.1	57.19	12 35.19	0.682	6 7 22.1	16 3.5
9	6 30 0.4	56.99	12 51.34	0.663	6 30 12.6	16 3.7
10	6 52 45.6	56.77	13 7.01	0.643	6 52 58.0	16 4.0
11	7 15 25.4	56.54	13 22.18	0.622	7 15 38.0	16 4.3
12	7 37 59.5	56.29	13 36.84	0.600	7 38 12.3	16 4.5
13	8 0 27.3	56.02	13 50.97	0.577	8 0 40.3	16 4.8
14	8 22 48.6	55.74	14 4.54	0.554	8 23 1.6	16 5.1
15	8 45 2.8	55.44	14 17.55	0.530	8 45 16.0	16 5.3
16	9 7 9.6	55.12	14 29.98	0.506	9 7 22.9	16 5.6
17	9 29 8.6	54.78	14 41.82	0.481	9 29 22.0	16 5.9
18	9 50 59.3	54.43	14 53.05	0.455	9 51 12.8	16 6.2
19	10 12 41.4	54.06	15 3.66	0.429	10 12 55.0	16 6.4
20	10 34 14.4	53.68	15 13.63	0.402	10 34 28.1	16 6.7
21	10 55 38.0	53.28	15 22.96	0.375	10 55 51.7	16 7.0
22	11 16 51.7	52.86	15 31.63	0.347	11 17 5.4	16 7.2
23	11 37 55.1	52.42	15 39.62	0.319	11 38 8.8	16 7.5
24	11 58 47.8	51.97	15 46.93	0.290	11 59 1.5	16 7.8
25	12 19 29.4	51.49	15 53.55	0.261	12 19 43.1	16 8.1
26	12 39 59.5	51.01	15 59.46	0.231	12 40 13.1	16 8.3
27	13 0 17.7	50.50	16 4.65	0.201	13 0 31.2	16 8.6
28	13 20 23.6	49.98	16 9.10	0.170	13 20 37.1	16 8.8
29	13 40 16.9	49.45	16 12.81	0.139	13 40 30.2	16 9.1
30	13 59 57.1	48.89	16 15.75	0.107	14 0 10.3	16 9.4
31	14 19 23.8	48.32	16 17.92	0.074	14 19 36.9	16 9.6
32	S. 14 38 36.7	47.74	16 19.29	0.040	S. 14 38 49.7	16 9.9

* The Semidiameter for Apparent Noon may be assumed the same as that for Mean Noon.

NOVEMBER, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be sub. from Apparent Time.		AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.			Apparent Declination.	Semi- diameter.*
	° ' "	"	m s	s	° ' "	' "
1	S. 14 38 36.7	47.74	16 19.29	0.040	S. 14 38 49.7	16 9.9
2	14 57 35.4	47.14	16 19.86	0.007	14 57 48.2	16 10.1
3	15 16 19.5	46.53	16 19.61	0.027	15 16 32.2	16 10.4
4	15 34 48.7	45.90	16 18.54	0.062	15 35 1.2	16 10.6
5	15 53 2.6	45.25	16 16.63	0.097	15 53 14.8	16 10.8
6	16 11 0.7	44.59	16 13.87	0.133	16 11 12.8	16 11.1
7	16 28 42.7	43.90	16 10.25	0.169	16 28 54.5	16 11.3
8	16 46 8.1	43.21	16 5.77	0.205	16 46 19.7	16 11.5
9	17 3 16.6	42.49	16 0.43	0.241	17 3 28.0	16 11.7
10	17 20 7.7	41.76	15 54.22	0.277	17 20 18.8	16 12.0
11	17 36 41.0	41.01	15 47.14	0.313	17 36 51.7	16 12.2
12	17 52 56.0	40.24	15 39.20	0.349	17 53 6.5	16 12.4
13	18 8 52.4	39.45	15 30.39	0.885	18 9 2.6	16 12.6
14	18 24 29.7	38.65	15 20.71	0.421	18 24 39.6	16 12.8
15	18 39 47.5	37.83	15 10.19	0.456	18 39 57.1	16 13.0
16	18 54 45.5	36.99	14 58.82	0.491	18 54 54.7	16 13.2
17	19 9 23.2	36.14	14 46.61	0.526	19 9 32.1	16 13.4
18	19 23 40.2	35.27	14 33.57	0.560	19 23 48.8	16 13.6
19	19 37 36.2	34.39	14 19.71	0.594	19 37 44.4	16 13.8
20	19 51 10.8	33.49	14 5.05	0.627	19 51 18.6	16 14.0
21	20 4 23.5	32.57	13 49.60	0.660	20 4 31.0	16 14.2
22	20 17 14.1	31.64	13 33.37	0.692	20 17 21.2	16 14.4
23	20 29 42.2	30.69	13 16.37	0.724	20 29 49.0	16 14.6
24	20 41 47.4	29.73	12 58.62	0.755	20 41 53.8	16 14.8
25	20 53 29.4	28.76	12 40.14	0.785	20 53 35.4	16 15.0
26	21 4 47.8	27.77	12 20.93	0.815	21 4 53.5	16 15.2
27	21 15 42.4	26.77	12 1.01	0.844	21 15 47.8	16 15.3
28	21 26 12.9	25.76	11 40.40	0.873	21 26 17.9	16 15.5
29	21 36 18.9	24.74	11 19.11	0.901	21 36 23.6	16 15.7
30	21 46 0.2	23.70	10 57.16	0.928	21 46 4.6	16 15.8
31	S. 21 55 16.2	22.66	10 34.56	0.955	S. 21 55 20.6	16 16.0

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

DECEMBER, 1876.

Day of the Month.	AT APPARENT NOON THE SUN'S		Equation of Time to be subt. from		Var. in 1 hour.	AT MEAN NOON THE SUN'S	
	Apparent Declination.	Var. in 1 hour.	added to Apparent Time.	Apparent Declination.		Semi- diameter.*	
	° ' "	"	m s	s		° ' "	' "
1	S. 21 55 16.6	22.66	10 34.56	0.955	S. 21 55 20.6	16 16.0	
2	22 7.8	21.60	10 11.32	0.981	22 4 11.4	16 16.1	
3	22 12 33.4	20.53	9 47.47	1.006	22 12 36.7	16 16.3	
4	22 20 33.3	19.45	9 23.03	1.030	22 20 36.3	16 16.4	
5	22 28 7.2	18.37	8 58.02	1.054	22 28 10.0	16 16.5	
6	22 35 14.9	17.27	8 32.46	1.076	22 35 17.4	16 16.6	
7	22 41 56.1	16.16	8 6.38	1.097	22 41 58.3	16 16.7	
8	22 48 10.5	15.04	7 39.79	1.118	22 48 12.4	16 16.8	
9	22 53 57.9	13.91	7 12.73	1.137	22 53 59.6	16 17.0	
10	22 59 18.2	12.78	6 45.23	1.154	22 59 19.7	16 17.1	
11	23 4 11.2	11.64	6 17.32	1.171	23 4 12.4	16 17.2	
12	23 8 36.7	10.48	5 49.03	1.186	23 8 37.7	16 17.3	
13	23 12 34.4	9.33	5 20.40	1.200	23 12 35.3	16 17.4	
14	23 16 4.4	8.17	4 51.45	1.212	23 16 5.1	16 17.4	
15	23 19 6.5	7.00	4 22.24	1.222	23 19 7.0	16 17.5	
16	23 21 40.5	5.83	3 52.79	1.231	23 21 40.9	16 17.6	
17	23 23 46.4	4.66	3 23.14	1.239	23 23 46.7	16 17.7	
18	23 25 24.1	3.48	2 53.34	1.244	23 25 24.3	16 17.7	
19	23 26 33.6	2.31	2 23.42	1.248	23 26 33.7	16 17.8	
20	23 27 14.8	1.13	1 53.42	1.251	23 27 14.8	16 17.9	
21	23 27 27.6	0.06	1 23.37	1.252	23 27 27.6	16 18.0	
22	23 27 12.0	1.24	0 53.31	1.252	23 27 12.0	16 18.0	
23	23 26 28.1	2.42	0 23.28	1.250	23 26 28.1	16 18.1	
24	23 25 15.9	3.60	0 6.68	1.246	23 25 15.9	16 18.1	
25	23 23 35.5	4.77	0 36.55	1.242	23 23 35.5	16 18.2	
26	23 21 26.8	5.95	1 6.29	1.236	23 21 26.9	16 18.2	
27	23 18 50.0	7.12	1 35.87	1.229	23 18 50.2	16 18.2	
28	23 15 45.1	8.29	2 5.26	1.220	23 15 45.4	16 18.2	
29	23 12 12.3	9.45	2 34.43	1.210	23 12 12.7	16 18.3	
30	23 8 11.6	10.60	3 3.35	1.199	23 8 12.2	16 18.3	
31	23 3 43.3	11.75	3 31.99	1.187	23 3 44.0	16 18.3	
32	S. 22 58 47.4	12.90	4 0.32	1.174	S. 22 58 48.2	16 18.3	

* The Semidiameter for *Apparent Noon* may be assumed the same as that for *Mean Noon*.

STARS DECLINATION.

January 7th,	Sirius,	16° 34' 46'' S.
February 30th,	Aldebaran,	16° 15' 37'' N.
March 19th,	Arcturus,	19° 49' 25'' N.
May 18th,	a. Hydrae,	8° 7' 27'' S.
June 20th,	Achernar,	57° 51' 33'' S.
July 10th,	Aldebaran,	16° 15' 40'' N.
August 31st,	Rigel,	8° 20' 26'' S.
September 20th,	Regulus,	12° 34' 18'' N.

EXTRACTS FROM ADMIRALTY TIDE TABLES, 1873.

FOREIGN PORTS.

Date.	Name of Port.	A. M. Tides.	P. M. Tides.	Moon's Transit	High Water at Full & Change.	
		h. m.	h. m.	h. m.	h. m.	Long.
Jan. 29th,	St. John, N. B.,	4 5	4 30	1 7		
" 30th,		4 54	5 17	2 4	11 21	66° W.
May 31st,		6 44	7 7	4 27		
June 1st,	Trencomalie (Ceylon),	7 30	7 54	5 13	8 18	80° E.
July 31st,		7 44	8 3	5 11		
August 1st,	Halifax, N. S.,	8 24	8 48	5 54	7 49	63° W.
Sept. 30th,		9 15	10 4	7 3		
Oct. 1st,	Kyau-Chau (Yellow Sea),	10 57	11 47	7 14	5 00	120° E.
Feb. 27th,		3 51	4 14	8 2		
" 28th,	St. John, N. B.,	4 36	4 58	0 42	11 21	66° W.
May 22nd,	Pei-ho (Yellow Sea),	0 7	0 35	1 34	3 40	122° E.
" 23rd,		1 3	1 30	8 41		
Dec. 19th,	Parrsboro', N. S.,	3 5	3 26	9 29	0 17	65° W.
" 20th,		3 48	4 10	11 41		
Sept. 1st,	Hakodadi (Japan),	9 38	10 23	a.0 40		
" 2nd,		11 11	11 57	7 14	5 0	135° E.
Nov. 22nd,	Yarmouth, N. S.,	4 40	4 59	8 15		
" 23rd,		5 18	5 39	1 52	10 9	66° W.
Oct. 11th,	New York, U. S.,	6 45	7 09	a.0 50		
" 12th,		7 34	8 00	4 11	8 13	74° W.
				5 7		

EXTRACT FROM ADMIRALTY TIDE TABLES, 1873.

HOME PORTS.

Date.	Name of Port.	A. M. Tides	P. M. Tides	Constant	Port of Reference.
		h. m.	h. m.	h. m.	
May 2,				+ 4 2	Brest.
" 3,		7 52	8 19		
" 4,	Cherbourg,	8 53	9 52		
" 20,	Exmouth,	11 41		+ 0 38	Davenport.
" 6,	Baltimore,		0 30	— 38	Queenstown.
June 24,	Cromarty,	1 40	2 1	— 2 21	Leith.
" 25,	Do.,	2 23	2 44	Do.,	"
Jan'y 7,		11 29			
" 8,	Ballycotton	0 3	0 37	— 0 26	Waterford.
" 9,		1 9	1 14		
Feb'y 4,		11 20	11 43	+ 0 19	Weston-Supermare
" 5,	Bristol,		0 11		
" 6,	Do.,	0 43	1 21		
March 30,	Pt. Patrick,	0 54	1 16	— 0 58	Greenock.
"	Do.,	1 37	1 55		
March 4,	Do.,	10 33	10 58		
April 5,	Llanelly,	11 30		+ 4	
May 4,	Ballycastle,	3 41	4 18	— 4 18	Belfast.
" 5,	Do.,	4 57	5 34	—	
June 11,	Ordfordness		0 6	— 0 51	Harwich.
"	Do.,	0 27	0 48	Do.,	"
July 26,	Do.,	11 15	11 31		
" 27,	Douglass,	11 48		+ 1 1	Holly Head.
August 3,	Tanera,	0 11	0 33	— 1 51	Thurso.
" 31,		8 30	9 00		
Sept. 1,	Alderney,	9 38	10 23	+ 2 59	Brest.

ANSWERS TO PAPERS.

ANSWERS TO PAPER FIRST.

Multiplication 80730

Division 1·321

DAY'S WORK.

Dep. course S. 58° E. 1st. S. 15° W. 2nd. N. 17° E. 3d. S. 38° E. 4th. S. 18° E. 5th. S. 19° E. 6th. S. 11° W., current course N. 41° E., true course S. 28° E., dis. 43 miles, Lat. in $43^{\circ} 8' N.$, Long. $65^{\circ} 31' W.$

MERIDIAN ALTITUDE.

True Alt. $33^{\circ} 30'$. Dec. $23^{\circ} 1' 45''$. Lat. $33^{\circ} 28' 15'' N.$

PARALLEL.

Difference Long. 56·08 miles.

MERCATOR.

Course N. 17° W. Dis. 240·6.

TIDES.

Bristol 9h. 20m., A. M., 9h. 43m., P. M. St. John 1h. 13m., A. M., 1h. 37m., P. M.

AMPLITUDE.

Dec. $22^{\circ} 52' 21''$. True Amp. E. $33^{\circ} 01' 15''$. Deviation $22^{\circ} 31' 15'' E.$

CHRONOMETER.

Daily rate, 1s. 8t. Acc. rate, $57''$. G. date Jan. 4th. 7h. 18m. 35s. Dec. $22^{\circ} 44' 14'' S.$ True Alt. $16^{\circ} 32' 10''$. Equation 5m. 11s. Hour Angle 2h. 12m. 35s. Long. $75^{\circ} 11' 15'' W.$

AZIMUTH.

True Alt. $8^{\circ} 44' 51''$. Dec. $22^{\circ} 39' 27''$. Sum of Logs 9·064314. True Azimuth S. $13^{\circ} 20' E.$ Error $17^{\circ} 20' 54''$. Deviation $27^{\circ} 30' E.$

EX MERIDIAN.

G. Date Jan. 6th, 4h. 46m. 7s. H. Angle 21m. 27s. True

Alt. $23^{\circ} 29' 7''$. Dec. $22^{\circ} 31' 24''$ S. 1st Aug. 5m. 25s.
2nd Aug. 5m. 30s. Lat. $43^{\circ} 48' 34''$ N.

STAR.

Dec. $22^{\circ} 52' 40''$. True Alt. $60^{\circ} 23' 3''$. Lat. $52^{\circ} 29' 37''$.

DEVIATION.

Cor. Mag. Bearing N. $49^{\circ} 13'$ W. 1st. $4^{\circ} 29'$ W. 2nd.
 $18^{\circ} 44'$ E. 3rd. $23^{\circ} 2'$ E. 4th. $12^{\circ} 27'$ E. 5th. $5^{\circ} 41'$ E.
6th. $6^{\circ} 53'$ W. 7th. $23^{\circ} 33'$ W. 8th. $27^{\circ} 58'$ W.

Correct courses S. 38° E. N. 19° E.

Compass courses S. 55° W. W.

Ship's head N. $10^{\circ} 40'$ E. S. $15^{\circ} 20'$ W.

ANSWERS TO PAPER SECOND.

Multiplication 447837

Division 1.094

DAY'S WORK.

Dep. Course N. 67° E. 1st, Course N. 3° E. 2nd, Course
N. 43° E. 3rd, Course N. 57° E. 4th, Course N. 79° E.
5th, Course N. 43° W. 6th, Course N. 5° W. 7th, Current N.
 21° W. True Course N. 32° E. Dis. 67 miles. Lat. in 43°
 $48'$ S. Long. in $83^{\circ} 56'$ W.

MERIDIAN ALTITUDE.

True Alt. $49^{\circ} 19' 2''$. Dec. $15^{\circ} 12' 2''$. Lat. $55^{\circ} 52' 20''$.

PARALLEL.

Diff. Long. 1229 miles.

MERCATOR.

True Course N. $31^{\circ} 17' 33''$ E. Dist. 4294.4.

TIDES.

Penzance Oh. 10m. P. M. Hi-ide 6h. 48m. — 7h. 31m., P. M.

AMPLITUDE.

Dec. $14^{\circ} 17' 59''$. True Amp. E. $20^{\circ} 33' 36''$ S. Dev. 15°
 $33' 30''$ E.

CHRONOMETER.

Daily rate 4s. 9t. Acct. rate 38s. G. date Feb. 1st, 21h. 11m. 56s. Dec. $16^{\circ} 56' 44''$. True Alt. $14^{\circ} 28' 26''$. Equation 13m. 56s. H. Angle 1h. 48m. 30s. Long. $18^{\circ} 22' 30''$ E.

AZIMUTH.

True Alt. $17^{\circ} 20' 31''$. Dec. $10^{\circ} 52' 47''$. Sum of Logs 19.213089. True Azimuth $47^{\circ} 40' 24''$. Error $4^{\circ} 30' 24''$. Dev. $17^{\circ} 10' 24''$ E.

EX MERIDIAN.

G. Date Feb. 21st, 6h. 42m. 40s. True Alt. $22^{\circ} 7' 53''$. Dec. $10^{\circ} 54' 59''$. 1st Aug. 2m. 58s.; 2nd Aug. 6m. 16s. Lat. in $57^{\circ} 14' 30''$ N.

STAR.

Dec. $16^{\circ} 15' 37''$. Lat $43^{\circ} 53' 24''$ S.

DEVIATION.

Correct Mag. Bearing S. $40^{\circ} 24'$ W. 1st, $0^{\circ} 16'$ W.; 2nd, $20^{\circ} 14'$ E.; 3rd, $33^{\circ} 4'$ E.; 4th, $24^{\circ} 54'$; 5th, $1^{\circ} 6'$ W.; 6th, $25^{\circ} 46'$ W.; 7th, $32^{\circ} 16'$ W.; 8th, $18^{\circ} 36'$ W.

ANSWERS TO PAPER THIRD.

Multiplication 107755.7

Division 8.571

DAY'S WORK.

Dep. Course N. 67d. E. 1st, course N. 14d. E. 2nd, N. 20d. E. 3rd, N. 37d. E. 4th, course N. 5th, course N. 6d. E. 6th, course N. 16d. E. 7th, or dep. course, S. 17d. E. True course N. 24d. E. Dist. 141 miles. Lat. in 46d. 21m. S. Long. 179d. 25m. W.

MERIDIAN ALTITUDE.

Dec. 0d. 53m. 55s. True Alt. 89d. 6m. 54s. Lat. in 1d. 46m. 41s. S.

PARALLEL.

Diff. Long. 686 miles.

MERCATOR.

Course S. 64d. 54m. W. Dis. 2522 miles.

TIDES.

Wick 11h. 59m. A. M., no P. M. Grindstone Island 11h. 39m. A. M., 11h. 59m. P. M.

AMPLITUDE.

G. Date March 18th, 0h. 22m. 50s. Dec. 0d. 18m. 49s. Dev. 11d. 17m. 20s. E.

CHRONOMETER.

Daily rate 3s. 6t. Acct. rate 2m. 56s. 4t. G. date March 25th, 1h. 52m. 11s. Dec. 2d. 4m. 58s. True Alt. 30d. 40m. 17s. Equation 5m. 54s. Hour Angle 3h. 53m. 24s. Long. 84d. 55m. 15s. W.

AZIMUTH.

True Alt. 18m. 58m. 8s. Dec. 2d. 13m. 52s. Sum of Logs 19·510903. True Azimuth N. 69d. 25m. E. Error 5d. 54m. 40s. W. Deviation 20d. 24m. 40s. W.

EX MERIDIAN.

G. Date March 18th, 14h. 30m. 24s. Dec. 0d. 27m. 25s. S. True Alt. 43d. 18m. 5s. 1st Aug., + 0m. 13s.; 2nd Aug., + 23m. 30s. Lat. 45d. 51m. 00s. N.

STAR.

Dec. 19d. 49m. 25s. Lat. 39d. 39m. 16s. S.

DEVIATION.

Correct Mag. Bearing S. 47d. 53m. E. 1st, 4d. 33m. W.; 2nd, 18d. 37m. E.; 3rd, 23d. 47m. E.; 4th, 12d. 37m. E.; 5th, 5d. 57m. W.; 6th, 6d. 43m. W.; 7th, 28d. 23m. W.; 8th, 21d. 23m. W.

Correct courses N. 22d. 30m. W. N. 67d. 30m. W.

Compass courses S. 68d. E. N. 57d. 30m. E.

ANSWERS TO PAPER FOURTH.

Multiplication 148131·8

Division 10·00

DAY'S WORK.

Dep. course N. 62d. E.; 1st, course S. 81d. W.; 2nd, course N. 1d. W.; 3rd course N. 3d. W.; 4th, course N. 53d. E.; 5th, course N.; 6th, course N. 19d. W.; 7th, or dep. course N. 80d. E.; true course N. 8d. E. Distance 99 miles. Lat. in 44d. 19m. N. Long. in 61d. 2m. W.

MERIDIAN ALTITUDE.

Dec. 8d. 15m. 55s.. True Alt. 23d. 4m. 41s. Lat. in 65d. 10m. 40s. N.

PARALLEL.

Diff. Long. 185·7 miles.

MERCATOR.

Course N. 51d. 36m. W. Dis. 4910 miles.

TIDES.

Anticosti 0h. 24m. A. M., 0h. 46m. P. M. Banjoewangie No A. M., 0h. 18m. P. M.

AMPLITUDE.

G. Date 10th April, 23h. 32m. 10s. Dec. 8d. 10m. 40s. T. Amplitude E. 25d. 14m. N. Error 20d. 54m. 30s. W. Deviation 10d. 34m. W.

CHRONOMETER.

Daily rate 3s. 1t. Acct. rate 5m. 25s. G. date 19th, 15h. 50m. 27s. Dec. 11d. 37m. 34s. T. Alt. 32d. 12m. 53s. Equation 1m. 10s. Hour Angle 3h. 50m. 16s. Long. 179d. 39m. 45s. E.

AZIMUTH.

True Alt. 9d. 54m. 42s. Dec. 8d. 4m. 27s. Sum of Logs 19·702196. True Az. S. 90d. 25m. W. Error 10d. 35m. E. Deviation 0d. 16m. 15s. E.

EX MERIDIAN.

G. Date April 30th, 3h. 41m. 58s. Dec. 15d. 00m. 52s. True

Alt. 47d. 28m. 34s. 1st Aug., + 2m. 37s.; 2nd Aug., 10m. 41s. Hour Angle 17m. 58s. Lat. 57d. 24m. 14s. N.

DEVIATION.

Correct Mag. Bearing S. 1d. 21m. 30s. 1st. 0d. 49m. E.; 2nd, 2d. 41m. E.; 3rd, 10d. 51m. E.; 4th, 13d. 31m. E.; 5th, 2d. 31m. E.; 6th, 10d. 59m. W.; 7th, 12d. 39m. W.; 8th, 5d. 9m. W.

Correct course N. 26d. 00m. E. S. 70d. 20m. W.

Compass course S. 49d. 00m. W. S. 8d. 00m. W.

Ship's head S. 16d. 30m. E. N. 6d. 40m. W.

ANSWERS TO PAPER FIVE.

Multiplication 13690·97

Division 1·142

DAY'S WORK.

Dep. course N. 16d. E. 1st, S. 80d. E.; 2nd, course N. 88d. E.; 3rd, N. 1d. W.; 4th, N. 14d. W.; 5th, N. 3d. W.; 6th, S. 89d. E.; 7th or dep. course, N. 77d. E. True course N. 42d. E. Dist. 110 miles. Lat. in 42d. 02m. N. Long. 39d. 02m. W.

MERIDIAN ALTITUDE.

G. Date May 13th, 3h. 26m. 40s. Dec. 18d. 34m. 31s. Alt. 81d. 26m. 21s. Lat. 27d. 8m. 10s. N.

PARALLEL.

Diff. Long. 436·3.

MERCATOR.

Course N. 49d. 43m. W. Dist. 943·5.

TIDES.

Isle D'Yew, 11h. 54m. A. M., no P. M. Batoo Barra, 11h. 26m. A. M., 11h. 54m. P. M.

AMPLITUDE.

G. Date 27th, 17h. 24m. Dec. 21d. 31m. 32s. True Amp. E. 35d. 39m. N. Error 38d. 28m. W. Deviation 10d. 28m. W.

CHRONOMETER.

G. Date 19th, 18h. 7m. 37s. Daily rate 1m. 4s. Acct. rate 2m. 2s. True Alt. 38d. 46m. 54s. Dec. 20d. 03m. 32s. Equation 3m. 42s. Hour Angle 2h. 53m. 11s. Long. 141d. 56m. 30s. E.

AZIMUTH.

G. Date 20th, 20h. 20m. 20s. True Alt. 52d. 49m. 27s. Dec. 20d. 17m. 30s. Sum of Logs 18.909105. True Az. S. 33d. 6m. E. Error 25d. 14m. E. Deviation 38d. 24m. E.

EX MERIDIAN.

G. Date 20th, 7h. 4m. True Alt. 40d. 53m. 48s. Dec. 20d. 10m. 24s. N. 1st Aug. 5m. 6s.; 2nd Aug. 12m. 9s. Lat. 69d. 9m. 33s. N.

STAR.

True Alt. 28d. 47m. 17s. Dec. 8d. 7m. 27s. S. Lat. 53d. 5m. 16s. N.

DEVIATION.

Correct Mag. Bearings N. 42d. 24m. W. 1st, 10d. 56m. E.; 2nd, 3d. 24m. W.; 3rd, 18d. 54m. W.; 4th, 24d. 44m. W.; 5th, 10d. 4m. W.; 6th, 10d. 6m. E.; 7th, 19d. 16m. E.; 8th, 15d. 56m. E.

True courses 1st, N. 27d. 30m. E.; 2d, S. 47d. 30m. W.

Compass courses 1st, N. 80d. 00m. E.; 2d, N. 68d. 30m. W.

Ship's head 1st, N. 5d. 30m. W.; 2nd, S. 29d. 20m. W.

ANSWER TO PAPER SIXTH.

Multiplication 25940000

Division 22.84

DAY'S WORK.

Dep. course S. 77d. E. 1st, course N. 13d. E.; 2nd, course N. 74d. E.; 3rd, course N. 16d. W.; 4th, course N. 52d. E.; 5th, course N. 89d. E.; 6th, course N. 24d. E.; current course N. 41d. E.; true course N. 44d. E. Dis. 196 miles. Lat. in 42d. 44m. N. Long. 78d. 49m. W.

MERIDIAN ALTITUDE.

G. Date 11th, 20h. 1m. True Alt. 44d. 28m. 4s Dec. 23d.
11m. 30s. Lat. 22d. 20m. 1s.

PARALLEL.

Diff. Long. 322°4. Long. in 176d. 18m. E.

MERCATOR.

Course S. 22d. 49m. E. Dis. 3507 miles.

TIDES.

Hellvoettestuis, 7h. 15m. A. M., 7h. 43m. P. M. Wangaruru,
11h. 48m. A. M., No P. M.

AMPLITUDE.

G. Date 3rd, 5h. 42m. 40s. Dec. 22d. 25m. 36s. True Amp.
W. 39d. 28m. N. Error 4d. 19m. E. Dev. 10d. 22m. E.

CHRONOMETER.

G. Date 19th, 18h. 2m. 36s; rate 5s. gaining; acc. rate 2m.
34s. Dec. 23d. 27m. 2s. True Alt. 39d. 1m. 15s. H. Angle
3h. 34m. 36s. Equation 1m. 16s. Long. 36d. 01m. E.

AZIMUTH.

G. Date 7h. 59m. 40s. Alt. 16d. 59m. 5s. Dec. 23d. 20m.
43s. N. Sum of Logs 19·815487. True Azimuth S. 107d. 55m.
W. Error 89d. 06m. Dev. 31d. 35m. W.

EX MERIDIAN.

G. Date 14th, 48m. 10s. Hour Angle 27m. 6s. True Alt.
50d. 18m. 55s. Dec. 22d. 41m. 20s. 1st Aug. 8m. 30s. 2nd
Aug. 24m. 56s. Lat. 62d. 6m. 15s. N.

STAR.

True Alt. 47d. 1m. 7s. Dec. 57d. 51m. 33s. Lat. 14d. 52m.
30s. S.

DEVIATION.

Correct Mag. Bearing N. 1d. 30m. W. 1st, 3d. 40m. W.
2nd, 11d. 55m. E. 3rd, 13d. 30m. E. 4th, 6d. 40m. E. 5th,

1d. 40m. E. 6th, 3d. 35m. W. 7th, 11d. 40m. W. 8th, 14d. 30m. W.

True Courses, N. 38d. E., N. 88d. 30m. W.

Compass Courses, S. 28d. W., N. 14d. W.

Ship's head, N. 36d. 40m. E. S. 61d. 30m. W.

ANSWERS TO PAPER SEVENTH.

Multiplication, 78699·8.

Division, 11·4436.

DAY'S WORK.

Dep. course S. 16d. W. 1st, course S. 86d. W.; 2nd, course S. 89d. W.; 3rd, course S. 86d. W.; 4th, course S. 80d. W.; 5th, course S. 75d. W.; 6th, course S. 89d. W. Current course S. 1d. E. True course S. 73d. W. Dist. 122 miles. Lat. in 50d. 49m. N. Long. in 12d. 34m. W.

MERIDIAN ALTITUDE.

True Alt. 69d. 30m. 32s. Dec. 20d. 37m. 00s. N. Lat. 41d. 06m. 28s. N.

PARALLEL.

Diff. Long. 180·6.

MERCATOR.

Course N. 34d. 25m. E. Dist. 7606·4.

TIDES.

Quillieboeuf, 00h. 33m. A. M., 00h. 51m. P. M. Hokianga, 00h. 24m. A. M., 00h. 42m. P. M.

AMPLITUDE.

G. Date 30th, 10h. 10m. Dec. 18d. 16m. 52s. True Amp. E. 23d. 52m. N. Dev. 00d. 12m. W.

CHRONOMETER.

G. Date 24th, 8h. 22m. 48s. Daily rate 8s. 4t.; acc. rate 3m. 18s. 7t. True Alt. 29d. 15m. 26s. Dec. 19d. 41m. 14s. Equation + 6m. 14s. H. Angle 2h. 49m. 54s. Long. 166d. 37m. 30s. W.

AZIMUTH.

G. Date 30th, 16h. 30m. 40s. True Alt. 46d. 42m. 46s. Dec. 18d. 13m. 00s. N. True Azimuth N. 19d. 40m. E. Error 28d. 00m. W. Deviation 20d. 30m. W.

EX MERIDIAN.

G. Date 29th, 2h. 40m. True Alt. 41d. 28m. 18s. Dec. 18d. 36m. 12s. 1st Aug. 9m. 42s.; 2nd Aug. 25m. 40s. Lat. 66d. 51m. 54s. N.

STAR.

True Alt. 48d. 17m. 24s. Dec. 16d. 15m. 40s. N. Lat. 57d. 58m. 51s. N.

DEVIATION.

Correct Mag. Bearing, N. 11d. 7m. E. 1st, 1d. 35m. W. 2nd, 6d. 0m. E. 3rd, 17d. E. 4th, 6d. E. 5th, 2d. W. 6th, 9d. W. 7th, 10d. W. 8th, 7d. W.

True Courses, N. 63d. 30m. E. S. 87d. W.

Compass Courses, S. 21d. E. N. 27d. 30m. W.

Ship's head, N. 18d. E. S. 69d. 30m. W.

ANSWERS TO PAPER EIGHTH.

Multiplication, 6909634·7. Division, 1·199.

DAY'S WORK.

Dep. course S. 63d. E. 1st, course S. 19d. E.; 2nd, course S. 72d. W.; 3rd, course S. 13d. W.; 4th, course S. 61d. W.; 5th, course N. 75d. W.; 6th, course S. 9d. W. Current course S. 43d. E. True course S. 18d. W. Dist. 87 miles. Lat. in 13d. 5m. N. Long. 176d. 51m. E.

MERIDIAN ALTITUDE.

True Alt. 51d. 48m. 9s. Dec. 12d. 22m. 54s. N. Lat. 50d. 34m. 46s. N.

PARALLEL.

Diff. Long. 391·5.

MERCATOR.

Course N. 86d. 7m. E. Dist. 6644.

TIDES.

Cardigan, 4h. 28m. A. M., 4h. 58m. P. M. Tracadie, 4h. 26m. A. M., 4h. 58m. P. M.

AMPLITUDE.

G. Date 24th, 19h. 19m. Dec. 10h. 38m. N. True Amp. E. 15d. 51m. N. Deviation 7d. 39m. E.

CHRONOMETER.

G. Date 14th, 20h. 58m. 40s. Daily rate 1s. 2t. losing; acc. rate 0m. 59s. True Alt. 10d. 42m. 30s. Dec. 13d. 55m. 24s. Equation + 4d. 12m. H. A. 4h. 11m. 3s. Long. 16d. 22m. 30s. W.

AZIMUTH.

G. Date 18th, 17h. 40m. True Alt. 46d. 41m. 27s. Dec. 12d. 40m. 58s. N. True Az. N. 43d. 42m. E. Error 8d. 28m. W. Deviation 8d. 52m. E.

EX MERIDIAN.

G. Date 2nd, 3h. 28m. 2s. Dec. 17d. 35m. 30s. True Alt. 42d. 14m. 5s. 1st Aug. 14m. 16s.; 2nd Aug. 40m. 2s. Lat. 65d. 35m. 40s. N.

STAR.

True Alt. 43d. 45m. 46s. Dec. 8d. 20m. 26s. Lat. 54d. 34m. 40s. S.

DEVIATION.

Correct Mag. Bearing N. 71d. 07m. W. 1st, 12m. 13s. E. 2nd, 43m. E. 3rd, 17d. 59m. W. 4th, 22d. 52m. W. 5th, 7d. 27m. W. 6th, 12d. 3m. E. 7th, 10d. 33m. E. 8th, 12d. 43m. E.

True Courses, N. 32d. W. S. 55d. E.

Compass Courses, S. 35d. E. N. 59d. W.

Ship's head, N. 11d. 45m. W. S. 15d. 20m. W.

ANSWERS TO PAPER NINTH.

Multiplication, 185809·82. Division, 15·218.

DAY'S WORK.

Dep. course N. 22d. E. 1st, course N. 11d. W.; 2nd, course N. 4d. E.; 3rd, course N. 46d. E.; 4th, course N. 69d. E.; 5th, course N. 88d. E.; 6th, course N. 66d. W. Current course N. 20d. E. True course N. 27d. 30m. E. Dist. 144 miles. Lat. in 53d. 17m. N. Long. 138d. 43m. W.

MERIDIAN ALTITUDE.

True Alt. 41d. 57m. 8s. Dec. 0d. 7m. 59s. S. Lat. 47d. 22m. 55s. N.

PARALLEL.

Diff. Long. 278·2.

MERCATOR.

Course S. 31d. 45m. E. Dist. 2364 miles.

TIDES.

Wells Bar, 11h. 39m. A. M., no. P. M. Tutukaka, 11h. 57m. A. M., no P. M.

AMPLITUDE.

G. Date Sept. 8th, 21h. 40m. Dec. 5d. 8m. 7s. True Amp. E. 5d. 40m. N. Dev. 10m. E.

CHRONOMETER.

G. Date Sept. 1st, 16h. 9m. 54s. Daily rate 2s. 4t. Ac. rate 30s. True Alt. 62d. 9m. 36s. Dec. 7d. 48m. 49s. Equation 30s. H. Angle 1h. 52m. 22s. Long. 130d. 29m. 30s. E.

AZIMUTH.

G. Date 1st, 18h. 26m. 50. True Alt. 34d. 20m. 25s. Dec. 7d. 47m. 42s. True Az. N. 72d. 8m. 48s. Error 8d. 21m. 12s. E. Deviation 13d. 1m. 12s. E.

EX MERIDIAN.

G. Date Sept. 9th, 12h. 17m. 14s. Dec. 4d. 54m. 16s. True
Alt. 68d. 22m. 21s. 1st. Aug. 14s.; 2nd Aug. 5m. 19s. Lat.
31d. 26m. 19s. N.

STAR.

True Alt. 61d. 13m. 43s. Dec. 12d. 35m. 32s. Lat. 41d.
21m. 49s. N.

DEVIATION.

Correct Mag. Bearing, N. 1d. 38m. W. 1st dev. 5d. 8m. W.
2nd, 14d. 48m. E. 3rd, 16d. 32m. E. 4th, 8d. 52m. E. 5th,
3d. 50m. E. 6th, 5d. 48m. W. 7th, 13d. 58m. W. 8th, 17d.
8m. W.

True Courses, N. 45d. W. S. 50d. E.

Compass Courses, S. 23d. W. S. 83d. E.

Ship's head, S. 28d. 30m. E. N. 75d. 40m. E.